THE FICTION
# of the
ICE AGE
with
SUPPLEMENT.

Price 2/6 Net.

dz

THE FICTION

OF THE

ICE AGE OR GLACIAL PERIOD

WITH

SUPPLEMENT

BY

FRANCIS D. LONGE,
Member of the Norfolk and Norwich Naturalists' Society.

> Quid verum, atque decens, curo et rogo, et omnis in hoc sum......
> Nullius addictus jurare in verba magistri.
>
> Hor. Epist. I.I.

CORRIGENDA—p. 71, for "bituminous shells" read "bituminous shales."

SUPPLEMENT, p. 2—Paragraph beginning "After noticing" should read "After noticing the hypotheses proposed by Sir C. Lyell."

SUPPLEMENT, p. 4—"Principles of Geology," reference should be to 10th, 11th and 12th Editions instead of 17th Edition.

1902-3:
McGREGOR & FRASER,
LOWESTOFT.

551.792
L857f

PREFACE.

SINCE the following pages were written, the attention of the writer has been called to the Supplementary article on "Geology," which appears in Volume XXVIII. of the "Encyclopædia Britannica" published last year, with the initials of Sir A. Geikie, and which contains a very important passage bearing on the subject of this treatise.

The author of the article says—

> "In this Supplementary article, it will be sufficient to call attention only to the more important changes of view and additions to our knowledge of the larger questions with which geology deals. The astronomical relations of the earth and their bearings on geological speculation have been much discussed in recent years. Of these questions more particular reference may here be made to two—Croll's doctrines as to the origin of the climates of the past, and the controversy as to the age of the earth.
>
> The ingenious views propounded by James Croll (1821-90) regarding the influence of astronomical causes in determining varieties of terrestrial climate, were fully stated in the Ninth edition article. His teaching was widely accepted by geologists, in as much as it seemed to offer a solution of one of the most difficult problems of geology, and to provide a possible basis for computing the absolute value of geological time. More recently his views were adopted with certain modifications and enforced by Sir Robert Ball, with his accustomed vigour." (See 'The Cause of an Ice-Age,' 1891,—noticed in the 3rd chapter of the following treatise).

Sir A. Geikie goes on to say that Mr. Croll's doctrine did not make way among physicists and astronomers, and refers particularly to the criticisms of some recent authorities, showing that it cannot be trusted as furnishing an explanation of the supposed cold of the "Glacial Period."

In concluding this part of his subject, he says—

> "The failure of the astronomical theory to afford a solution of the problem of the Ice Age leaves geologists once more face to face with one of the most perplexing questions with which they have to deal. At present no satisfactory explanation of it has been offered."

The renouncement by Sir A. Geikie of the doctrine on which Ramsay, Lyell, and Darwin relied when adopting the theory of the Glacial Period in Post-pliocene times, has greatly altered the position which the Story of the Ice Age has hitherto held in science, and would appear to favour very much the probability of the explanation submitted in the following pages being the true solution of this "perplexing question."

Lowestoft:
22nd August, 1903.

PART I.

CHAPTER I.

INTRODUCTORY—ORIGIN OF GLACIAL THEORY.— SIR A. GEIKIES' "STORY OF THE ICE AGE."

THE difficulty of proving a negative is proverbial, but an attempt will be made in the following pages to show that according to well established geological principles, as explained both by the expounders and upholders of the Glacial Theory, as well as by other authorities, there could not be evidence, still extant, to prove the occurrence of such an event as the "Glacial Period," or "Great Ice Age," in Pleistocene times, and that the facts, on which it is supposed to be based, can be satisfactorily explained by the operation of physical causes already well known, without the introduction of any such paradoxical and anomalous events, as either a change in the general climate of the earth, or any abnormal diluvial occurrence.

In the early part of the last century the main principles of Geology, as regards the older rocks, had been established, but the origin of the superficial deposits known as the "Drift" was still unexplained.

The explanation of the "Drift" furnished by the ancient story of the Noachian Deluge could never be accepted by scientists, although as late as 1824 we find one of our leading geological authorities putting forth a treatise to show that the "Drift" with its boulder-clay, and relics of extinct life forms, "attested the action of a Universal Deluge."*

---

*"Reliquiæ Diluvianae," by the Rev. William Buckland, Professor of Mineralogy and Geology in the University of Oxford, &c., 1824.

About the same time, researches in the Scotch mountains and valleys revealed evidence of the existence in former days of glaciers which have since entirely disappeared. These glacial phenomena were associated with the "Drift," known as the "Diluvial Drift." A theory was started, which was very readily welcomed by scientists and others, on the look-out for some explanation of the "Drift," not involving a miraculous interference with the operation of secondary causes, that this so called "Diluvial" Drift, was not produced by water, but by ice, either by floating ice-bergs, or by vast sheets of land ice, developed by the prevalence of greater cold than that of the present during a long period of time.

While geologists were discussing the evidence of this former ice action, the propounders of the theory of the ice sheets, found strong support in an astronomical theory, developed by the late Mr. Croll, according to which recurrent periods producing an intensity of cold alternately in the higher latitudes of both Hemispheres, were the necessary effect of the variation in the shape of the Earth's orbit.

Thus fortified, the exponents of the glacial theory gave free play to their imaginations, and the story of a glacial period, during which the climate of the Northern Hemisphere was greatly refrigerated from the pole to the equator, and vast ice sheets were developed in the northern and temperate latitudes, was put forward as a well attested event in geological history.

While fierce controversies raged among geologists as to the interpretation of the facts adduced as illustrations or proofs of the action of the great ice sheets, the occurrence of a glacial period of some kind seems to have been very generally accepted by geologists, apparently owing largely to the supposition of Lyell and other authorities, that the geological theory was supported to some extent by biological evidence, as well as by astronomical laws.

At length, towards the latter part of the last century, the astronomical theory of Mr. Croll was found unsatisfactory and fell into discredit, and the supporters of the ice sheet theory had to fall back upon geological evidence only.

Meanwhile the study of the surface features of this and other countries had been actively carried on, and the frequent occurrence of earth movements altering the areas of land and sea, as well as the surface contour of this and other countries in late times, has become a matter of general knowledge, while no new facts have been discovered to support the conception of the Glacial Hypothesis.

The following extract from Sir A. Geikie's "Class book of Geology," published in 1899, presents the reader with what may be regarded as the latest version of the story of the Ice Age, as told by the highest authority on the subject.*

In a preliminary passage, he says:—

> "The gradual refrigeration of climate which is revealed to us by the shells of the crag, was prolonged and intensified in Post-tertiary times. Ultimately the northern part of the Northern Hemisphere was covered with snow and ice, which extended into the heart of Europe, and descended far southward into North America. The previous denizens of land and sea were in large measures driven out, even in many cases wholly extirpated by the cold, while northern forms advanced southward to take their places. The reindeer, for instance, roamed in great numbers across Southern France, and Arctic vegetation spread over Central Europe, even as far as the Pyrenees. After the cold had reached its climax, the ice-fields began to retract and the Northern Fauna and Flora to retire before the advance of the plants and animals which had been banished by the increasingly severe temperature, and at last the present conditions of climate were reached.
>
> The story of this Ice Age is told by the Pleistocene or Post-Pliocene formations, while that of the changes which immediately led to the establishment of the present order of things is made known in the Recent Deposits."

Having thus given an epitome of the "story of the Ice Age," he heads the more detailed account of it by identifying the term "Glacial" with the terms "Pleistocene or Post Pliocene," as the title of the chronological period during which it prevailed, and then proceeds as follows:—

> "The evidence from which geologists have unravelled the history of the Ice Age or cold episode, which came after the Tertiary periods in the Northern Hemisphere, may be briefly given.

---

*See Chapter xxvii.

All over Northern Europe and the northern part of North America, the solid rocks, where of hardness sufficient to retain it, are found to present a characteristic smoothed, polished, and striated surface. Even on crags and rocky bosses that have remained for long periods exposed to the action of the weather, this peculiar worn surface may be traced; but where it has been protected by a covering of clay, these markings are often as fresh as when they were first made. There can be no doubt that all this smoothing, grooving, and striation, has been done by land ice.

As the ice travelled it carried with it more or less detritus, as a glacier does at the present day. Some of this material may have been on the surface, but probably most of it was pushed along at the bottom of the ice. Accordingly, above the ice-worn surface of the rock there lies a great deposit of clay and boulders, evidently the debris that accumulated under the ice sheet, and which was left on the surface of the ground when the ice retired. This deposit called "Boulder Clay" or "Till" bears distinct corroborative testimony to the movement of the ice. It is always more or less local in origin, but contains a variable proportion of stones which have travelled for a greater or less distance: sometimes for several hundred miles. When these stones are traced to their places of origin, which are often not hard to seek, they are found to have come from the same quarters as that indicated by the striation of rocks. If, for example, the ice-worn bosses of rock show the ice to have crept from north to south, the boulders will be found to have a northern origin. The height to which striated rock surfaces and scattered erratic blocks can be traced, affords some measure of the depth of the ice sheet. From this kind of evidence it has been ascertained that the whole of Northern Europe, amounting in all to probably not less than 770,000 square miles, was buried under one vast expanse of snow and ice. The ice sheet was thickest in the north and west, whence it thinned away southward and eastward. Upon Scandinavia it was not improbably between 6,000 and 7,000 feet thick. It has left its mark at heights of more than 3,000 feet in the Scottish Highlands, and over North-Western Scotland it was probably not less than 5,000 feet thick. Where it abutted upon the range of the Hartz Mountains it appears to have been still not far short of 1,500 feet in thickness. This vast mantle of ice was in continual motion creeping outward and downward from the high grounds to the sea. The direction taken by the principal currents can be still followed. In Scandinavia, as shown by the rock striae and the transport of boulders, it swept westward into the Atlantic, eastward into the Gulf of Bothnia, which it completely filled up, and southward across Denmark and the low grounds of Northern Germany. The basin of the Baltic was completely choked up with ice; so also was that of the North Sea as far south as the neighbourhood of London.

From the same evidence we know that the ice which streamed off the British Isles moved eastward from the slopes of Scotland into the hollow of the North Sea, part of it turning to the left to join the south-western margin of the Scandinavian sheet, and move with it northwards and westwards across the Orkney and Shetland Islands into the Atlantic, and another branch bending southward and moving with the southerly expansion of the

> Scandinavian ice, along the floor of the North Sea and the low grounds of the east of England; and that on the west side of Scotland the ice filled up and crept down all the fiords, burying the western islands under its mantle and marching out into the Atlantic. The western margin of the ice fields—from the south-west of Ireland to the North Cape of Norway—must have presented a vast wall of ice, some 2,000 miles long, and probably several hundred feet high, breaking off into ice-bergs, which floated away with the prevailing currents and winds. The Irish Sea was likewise filled with ice moving in a general southerly direction. Northern Europe must have presented the aspect of North Greenland at the present time. The evidence of rock striae and ice-borne blocks enable us to determine approximately the southern limit to which the great Ice Cap reached. As even the south coast of Ireland is intensely ice-worn, the edge of the ice must have extended some distance beyond Cape Clear, rising out of the sea with a precipitous front, that faced to the south. Thence the ice cliff swung eastward, passing probably along the line of the Bristol Channel, and keeping to the north of the Valley of the Thames."

We do not intend to criticise this account of the "Story of the Ice Age" in all its details, but the reader will have observed that as the writer has told the story, it is not easy to distinguish statements intended to express facts of observation from statements intended only to express facts of inference. The writer states that the whole of Northern Europe has been ascertained to have been buried under snow and ice. Such a fact can clearly only have been ascertained by inference from facts of observation. That this Great Northern Ice Sheet, its course and its effects, are only facts of inference, whether the inferences are his own, or those of others, the writer himself would be ready to admit.

As to the "Kind of Evidence" or facts of observation from which the great northern ice sheets have been "ascertained" to have spread over Europe, the writer mentions particularly (1) the smoothed, polished and striated surfaces of solid rocks, which he at once appropriates as evidence by the statement: "*There can be no doubt that all this smoothing, grooving and striation has been done by land ice;*" (2) the deposits of clay and boulders (boulder-clay), found lying on these rocks, "*which is evidently the debris that accumulated under the Ice Sheet.*"

These two dogmas form the foundation of the whole glacial theory.*

NOTE:—The italics in the above passage and in the following Chapters are inserted by the writer of this treatise.

* See Part II., Chapter II.

CHAPTER II.

IN considering this account of the course taken by the great ice sheet, which is supposed to have travelled over these parts, the story appears on the face inconsequent and unintelligible. We are told that it covered the whole of Ireland, extending to the South Coast, where it rose with a precipitous front to the south, that it filled the Irish Channel, but that it did not extend in England lower than the Bristol Channel and the Thames Valley. It however covered East Anglia, and filled the North Sea as far south as London. On the European continent, as we are further told, it covered the whole of Northern Germany down to the mountains of Bohemia, and the whole of Russia, so far as Nijni Novgorod; and that when these ice sheets were spreading over Europe another great ice sheet was travelling over North America; and we are asked to believe, that notwithstanding this vast extension of these great ice sheets, that which travelled over the British Isles did not reach Wiltshire or Devonshire or Cornwall, and that while it covered Norfolk and Suffolk and Essex, it did not extend to Kent and Sussex.

Persons who have not a strong taste for scientific paradox, would be inclined to suspect some misinterpretation of the facts on which the course taken by the northern ice sheet in these parts was supposed to be shown, and wonder what the facts could possibly be which could prove the presence of the ice sheet in the Midland and Eastern Counties and on the South coast of Ireland, and its absence from the South of England.*

---

* See Part V.

It might also be observed as a preliminary criticism, that the conception of an enormous ice sheet moving over land, and polishing, grooving and striating the rocks over which it travelled would appear to be altogether a false conception. An "Ice Sheet" is only another name for an "Ice Cap." An "Ice Cap" is an accumulation of congealed snow, which whether represented by the "Ice Cap" which now covers the greater part (not the whole) of the surface of Greenland, or by the fjelds of Norway, is a stationary, not a moving mass, except so far as its component particles are moved slowly towards the glaciers, by which it is drained, as a lake is drained by rivers flowing from it.

The smoothing and groovings on rock surfaces, where they are not the work of flowing water, can only tell of glaciers flowing slowly down the mountain side, or the slopes of highlands from the snow caps on their summits. This criticism is not new. It is met by the explanation that the ice sheets of the Glacial Period, were to the snow caps of Greenland, or other Arctic areas of the present day, as mountains to molehills, and their powers as those of the Titans to the power of the Milos and Samsons of historic times.

The relics of ancient glaciers in a mountainous area, such as the Grampians in Scotland, may be so abundant as to furnish reasonable ground for assuming that at one time this range was covered to a great extent with a permanent mass of accumulated snow. Similar evidence might suggest a great accumulation of snow on the Kerry Mountains in Ireland, the Snowdon Range in Wales, the mountains of the Lake District, or the Pennine Chain in England, and the mountains of Norway, but they could not furnish any reasonable foundation for a belief that there was one continuous ice cap extending over the whole area of sea and land, in which these mountain ranges are comprised.

It appears, however, from this account, that Sir A. Geikie has assumed that the whole of the intervening area was covered with an ice sheet, the depth of which is to be ascertained by the height of the glacier markings still existing on the mountains which formed its borders, or which it is supposed to have reached. It is clear that assuming the low grounds intervening between these mountain ranges were covered with snow and ice, such features as deposits of clay or scratched rocks could furnish no evidence of the depth of ice, any more than of the water with which they might have been overflowed. Such a mode of estimating the depth and extent of the ice sheet is clearly based upon an entirely different ground than the evidence of old glaciers in these islands.

This picture of the great northern ice sheet has been reproduced by Professor James Geikie in his volume just published,* and the same mode of estimating its extent and depth adopted.

> "At the climax of the Glacial Period a great Ice Sheet covered all Northern and North Western Europe, extending east from the British area to the Timan Mountains, and south to the German Ranges. The ice sheet thus occupied an area of 2,500,000 square miles, or thereabouts, in extent. Above the surface of this inland ice peered some of the loftier mountain tops of Scandinavia, and a few Nunnatakkr in the British Islands. In the low grounds of Scotland the sheet could hardly have averaged less than 2,500 to 3,000 feet in thickness. In some of the Norwegian fiords it exceeded 3,500 feet. Taking the elevation of the ice shed in Scandinavia as 7,000 feet, and the height reached by the ice top upon the northern slopes of the mountains of Germany as 1,350 feet, we get a thickness for the ice sheet in South Sweden of 2,900 feet, of 2,500 in Denmark, and of 1,300 feet or thereabouts in the neighbourhood of Berlin."

In this passage, Professor J. Geikie reproduces the picture of the northern ice sheet, as given above by Sir A. Geikie, with an air of confidence in its reality which is quite startling. The writer assumes a knowledge of this ice deluge so complete, that he is able to give an estimate of the area covered by it in square miles, and to state precisely its depth in feet at every part of its extent, by drawing an imaginary line from the top of the mountains in Norway to the mountains of Germany. But why, if the existence and extent of these ice sheets is not altogether speculative or fictitious, does he differ so much from Sir A. Geikie as to enlarge its dimensions to nearly four times, from 770,000 to 2,500,000 square miles? Does this discrepancy mean a difference in the extent of the ice sheet described by the two writers, or some mistake by one or the other in calculating the mileage, or is each writer at liberty to represent the extent of this ice sheet according to his own will and pleasure?

---

* See "Earth Sculpture" p. 186.

As regards the depth of the ice sheet, we do not question that "taking the elevation of the ice shed in Scandinavia at 7,000 feet, and the height reached by the ice top upon the northern slopes of the mountains of Germany at 1350 feet," and assuming, (1) that the levels of the intervening area are known, and ; (2) that the intervening area was filled up with ice to the level of the imaginary inclined line, the depth of the ice at any part between these several ranges could be precisely calculated. But when we consider that this ice sheet, if it ever was in existence, is not in existence now, but is supposed to have existed at some period many tens of thousands of years ago, this mode of treating the subject implies knowledge which the writers, could not possibly possess. Notwithstanding the realistic details which have been introduced into these accounts we submit that there is no true ground either in nature or science for the assumption, either that the mountains in Pleistocene times were at the same height they are now, or that the contour of the intervening area was the same, or that it ever was covered with an ice sheet.

In assuming that the geography of the British Isles, at an early part of the Pleistocene age, was the same as that of the present day, the original inventors of the glacial theory fell into the same error as the old Hebrew poets, who in telling the story of the Flood, represented Noah's Ark as coming to rest on the top of Mount Ararat. The old naturalists were studying and puzzling over the same geological phenomena as those which the "Diluvialists" and the "Glacialists" quarrelled over in the middle of the last century. They saw the same Drift Deposits spread over the lowlands, containing fragments of rock brought from some distant and unknown source, with the bones of extinct animals and the relics of man, telling plainly of the destruction of a former life period, and with a bold effort of the imagination they attributed the phenomena to a great and exceptional cause, viz., a miraculous Deluge.

That the same erroneous assumption should be adopted by modern scientists can be explained, when we find that the glacial theory was in its origin nothing else than a substitution of ice for water, in the genesis of the "Diluvial Drift." A story which was to explain the origin of the Drift, by ice sheets instead of a Deluge (either of the miraculous kind as conceived by the old Hebrew writers, or as represented by the more scientific conceptions of the "diluvialists" in the early part, or of Sir Henry Howorth in the latter part, of the last century), must have been represented as occurring when the British Isles and other countries affected by it, were in much the same condition, as to geographical arrangements, as well as to surface contour, as they now are. But unless the supposed ice age was a short period, beginning and ending at no great distance, geologically speaking, from the present day, it is a necessary inference from the well established principles of geological science, that subaerial denudation would have greatly altered the surface contour of both highlands and lowlands comprised in the area supposed to be covered by these ancient ice sheets; even supposing that earth movements had not occurred to destroy altogether its former character and conditions.

The difficulties which the inventors and upholders of the glacial hypothesis have had to contend with, in maintaining the original conception, and adapting it to meet the ever increasing evidence which the advance of geological knowledge brought against them,—the frequent occurrence of earth movements, changes in the areas of land and sea, and the effects of subaerial denudation in lowering mountains and changing the surface contour of this and every other land area, together with the bold and ingenious devices by which they have endeavoured to meet them, will be shown in the following pages.

In his introduction to the second edition of the "Great Ice Age," Professor J. Geikie, in discussing the old view of geologists, that the surface of the earth had not been subjected to any great convulsions since the advent of man, writes thus :—

> "Subsequent research had widened our views as to the magnitude of the physical changes of which man had been a witness. Not only have great alterations of climate taken place within the human period, but the distribution of land and sea also has undergone very considerable modifications. Seas have vanished and returned, wide areas of land have appeared and disappeared, broad and deep valleys have been hollowed out of solid rocks by running water."

The extent to which Britain was supposed by some of the earlier glacialists themselves to have been affected by earth movements appears from the account given by Sir A. Ramsay, in 1872, of the submergence of this island during the Glacial period. The story of the shells on Moel Tryfaen is a remarkable instance of the difficulties in which the constructors of the glacial theory found themselves, and the daring way in which they got over them. Having made up their minds that the very common drift deposit known as "Boulder-Clay" was the product of land ice, when they found layers of these deposits separated from each other by a different kind of deposit, implying clearly the action of flowing water, they were forced to infer that these separated deposits of "Boulder-Clay" represented two (or more) separate and successive ice sheets, and that these successive ice sheets represented a succession of epochs of intense glaciation.

Having identified the lowest of the "Boulder-Clay" deposits as the deposits of the first ice sheet, it necessarily followed that the fact of a marine bed having been laid upon it, proved that the land in which these deposits were found had been submerged after the occurrence of the first ice sheet. As the deposit attributed to this first or oldest ice sheet, together with the remains of a marine deposit above it, were found very generally throughout England and Scotland, it was an unavoidable inference, that the beds of marine shells, found on high grounds in England and on Moel Tryfaen, were placed there after the deposit of the first "Boulder-Clay." As these shell deposits were found at altitudes of some 1,100 to 1,400 feet, it again necessarily followed that the whole country, or a large part of it, had sunk after the occurrence of the first land sheet to that depth at least beneath the sea, and been re-elevated afterwards to the same altitude.

Dispensing with the teaching of geological science, the constructors of the story boldly faced the difficulty, and did not hesitate to introduce this occurrence as part of their story, following it up with a picture of the British Isles reduced during the period of submergence to an archipelago of "icy islets," represented by the tips of Snowdon and Helvellyn, and other of the highest mountains in Wales and England, and of Ben Nevis and other high mountains in Scotland.*

Professor James Geikie followed Ramsay in representing this great submergence as occurring in the Glacial period, and after the period of maximum glaciation.‡ In his "Prehistoric Europe" (p. 18), Professor J. Geikie, in treating of the evidence of a submergence of land in the British Isles during the Glacial period, says (p. 780):—

> "There is clear evidence for example that considerable submergence supervened in the British Isles after the disappearance of the Ice Sheet of Maximum Glaciation, and before the advent of its successor."

However ready geologists might have been to believe with Lyell that this area had been subjected to frequent earth movements, involving changes in land and sea, the submergence of Britain to such an extent as this would so certainly have removed all evidence of "the Ice Sheet of maximum glaciation," that this submergence had to be omitted from the catalogue of events of the Ice Age, and another explanation of the shell deposits substituted.

---

* Ramsay's "Physical Geology and Geography of Great Britain" (p. 153).

‡ See his account in Woodward's "Geology of England and Wales," 1876, (p. 102).

In his account of the Glaciation of Scotland, Sir A. Geikie places its occurrence at a time when the geography and surface contour of the country was the same as now, and he gets over the difficulty of the sea shells in supposed glacial deposits, by attributing their presence not to submergence, but to the action of an ice sheet coming out of the sea like a monstrous sea serpent, and dropping the shells or their fragments about the surface over which it moved.

> "In some places the boulder clay contains marine shells. The highest level at which these have been met with in Scotland is 510 feet. At one time it was believed that the mere occurrence of such shells in a deposit, sufficed to prove the submergence of the locality, the minimum amount of depression being indicated by the height of the place above the sea level.
>
> But we now know that the ice-sheet of the glacial period was pushed along and out of some of the sea basins around our coasts. In the Moray Firth, as already stated, the ice slanted up over the low plains of Caithness, pushing along in its progress the mud, stones and shells that lay on the sea floor, and which are now found in the boulder-clay all over Caithness. The glacier that moved down the Firth of Clyde also ground up the clay and shells of the sea floor, as is shown by the shelly boulder-clay of the South of Arran, and the coast of Carrick and Wigtownshire." "Scenery of Scotland" (p. 366).

In mentioning 510 feet as the greatest height to which sea shells were raised in Scotland, he makes no allusion to the corresponding deposits discovered in England, on Moel Tryfaen and the highlands near Macclesfield. But if the shells were not placed there during the submergence of the places where they are found, the action of the same marvellous ice-lifts must be called in to explain their occurrence.

Nor are we surprised to find that some scientists, such as Mr. Belt and others, badly affected with the "glacial nightmare," did not hesitate to attribute their presence in these high altitudes to this cause, though it involved the belief that ice sheets could come out of the sea and mount up a land surface to the height of 1,400 feet or more.

But it is not necessary that a land surface should be submerged beneath the sea to be deprived of the evidence of its former character and contour.

In the following passages, we find Professor Geikie and Sir A. Geikie stating opinions as to the effect of subaerial denudation on land after it has been raised beyond the reach of the sea waves, which are quite irreconcilable with their assumed knowledge of the character and conditions of the surface of this or any other terrestrial area in the early part of the Pleistocene age.

In Mr. H. B. Woodward's "Geology of England and Wales," published in 1876, we find the following account of the views then expressed by Professor J. Geikie as to the effect of denudation on the evidence of old glaciers in this island :—

> " Mr. James Geikie has well observed that, even now, the action of the weather, of frost, rain, and rivers, is slowly but surely effacing the marks left by the old glaciers. And should our island eventually become submerged, it might well be, that, as the land sank down, what the atmospheric forces had failed to obliterate would succumb to the action of the sea ; and should the land be afterwards re-elevated, it is very doubtful indeed whether a single recognisable trace of former glacial work would remain." (p. 298).

In an article on "Geology" in the British Encyclopædia, published in 1879 (to which Sir A. Geikie gives his name), the writer, after noticing the disturbances of the crust from the action of internal forces of a volcanic nature, introduces a valuable exposition of the more modern theory, that the more general and effective cause of the movements of the crust is lateral pressure in the crust itself, resulting from contraction during the secular cooling of the earth. He finishes his account of this principle of Geological Dynamics with the following statement :—

> " But no sooner is a mass of land raised above the sea than it is subjected to the attack of rain, frost, springs and glaciers, and the other meteoric agents of disintegration. The surface is worn down, the flood of water down its slopes cuts out gulleys, ravines, and valleys, so that eventually a very rugged surface is produced, on which probably no portion of the original surface of upheaval will remain."

The previous part of this passage, explaining the Contraction Theory of earth movements, is quoted further on.* The concluding sentence quoted here is a clear statement of the writer's views as to the effect of subaerial denudation on the surface of any land, on and after its emergence from the sea, and is a very forcible confirmation of the passage cited above, as showing that whatever the surface might be, which the sea had allowed to pass through the destructive action of its waves, it would be removed in the course of years by the forces of subaerial denudation, to which it would be afterwards subjected. It is clear that the story of the Ice Age can only be reconciled with these principles by supposing that the geological facts on which it is founded, occurred after the last elevation above sea of each area, in which they have been discovered, and before the forces of denudation had had time to carry out fully their work of disfiguration.*

If we separate the facts of observation from the inferences drawn from them, and place the occurrence or production of those facts, at a time when they most certainly must have occurred, that is, after the surface containing them had been raised for the last time above sea, we might still see in them evidence of many old glaciers, which have since disappeared, and many "glacial epochs" in different countries, but of a very different and less imposing character than those of the Great Ice Age. The old glaciers would be nothing more than glaciers on mountain ranges which have since been lowered, and the "glacial epochs" would have been confined to these mountain ranges.

As the shells on Moel Tryfaen are for the most part of mollusca now living in the seas around us, their appearance on Moel Tryfaen points very forcibly to a movement of elevation occurring at no great distance from the present time, but it is only in the assumption of the glacialists that there would appear to be any reason for supposing that the part of

* See Part III., Chap. I.

this mountain, where the shells are embedded, was above sea level, before the movement which raised it to its present position, whatever altitudes the summits may have reached beyond that which they now retain.

The well preserved glacier markings on the rocks in the Pass of Llanberis in the same district, tell unmistakeably of the passage down this valley of a glacier from the higher parts of the Snowdon range at no very distant date, at all events at a time so recent that neither have earth movements since submerged the valley beneath the sea, nor altered its general shape, nor has subaerial denudation obliterated the records of the "Ice Tooth."

Such evidences in Britain and elsewhere, tell plainly of the existence of old glaciers, in mountainous regions, from which they have since disappeared, but they tell nothing of either ice sheets or glacial periods. The old glacier of the Llanberis valley was evidently nothing else than a glacier of the normal kind, which passed down the valley from the higher parts of the Snowdon range, which denudation has since wasted and reduced.

The constructors of the Ice Age story prudently abstained from dating the occurrence of this glacier at a time before the submergence and re-elevation of Snowdon. According to their account of the sequence of events in the glacial period, the period of intense cold, and of the great northern ice sheets, occurred before the supposed submergence. The glacier in the valley of Llanberis is represented as occurring at a much later period, when the great cold had already passed away, and when local glaciers only were developed.* The evidence of glacier movement in this valley tells far too plainly of its having been nothing more than a local glacier generated in the summits of Snowdon, to admit of its being misinterpreted as evidence of a great ice sheet coming from the north.

---

* See Professor J. Geikie's Summary, Woodward's op. cit. (p. 303). Ramsay's op. cit. (p. 157).

Considering the more northern latitude of Scotland, and the large extent of its mountain areas, it might reasonably be expected that more abundant evidence would be found there of the existence of glaciers produced under similar conditions, if not at the same time, as the old glacier of Snowdon. We have not to go beyond the ranks of the Geological Surveyors to find authority for the opinion, that the evidence of former glacial action in Britain, can be accounted for by the existence of local glaciers, developed by local conditions. Before noticing this heretical theory, we will call the reader's attention to the astronomical problem with which at one time the story of the Ice Age was intimately connected.

CHAPTER III.

ASTRONOMICAL THEORY OF ICE AGES.—MR. CROLL'S THEORY.—SIR R. BALLS' "CAUSE OF AN ICE AGE."

IT will have been observed that in the account given by Sir A. Geikie of the Story of the Ice Age, he attributes its authorship entirely to geologists, and bases its foundation exclusively on geological facts. He makes no allusion whatever to any cause of its occurrence, and leaves his readers entirely in the dark as to how and why this extraordinary and unique episode in geological history should have taken place. The original inventors of the story could not have treated the matter thus before the theory of the glacial period had got the footing in geological science, which for some reason or other it afterwards acquired. Such a paradoxical story could not have been launched without some suggestion at least of a physical cause. Such a cause was suggested by the astronomical theory of Mr. Croll. How much the first exponents of the geological theory relied upon the support of astronomers is clearly shown by the following passage from Sir A. Ramsay's account in his "Physical Geography and Geology of England and Wales (p. 150)."

After stating the geological grounds on which it was based he says:—

> "Therefore there can be no doubt that at late periods of the world's history a climate prevailed over large parts of the earth's surface generally, but not always, of Arctic severity, (for there were intermittent episodes of comparative warmth) the cold of these minor cycles in time, (for as shown by Mr. Croll, the glacial cycles alternated in the Northern and Southern Hemispheres), was produced by causes about which there have been many guesses, and which perhaps are only now beginning to be understood. According to Adhemar and Mr. Croll, the glacial episodes are due to an occasional excessive eccentricity of the earth's orbit. It is enough for the present argument if we realise the fact."

The astronomical principles on which Mr. Croll's theory was based were well known. Astronomers were well aware of the eccentricity of the earth's orbit round the sun being subject to variations which would cause a corresponding variation in the distance between the earth and sun in the summer and winter months, at different periods in the earth's secular revolutions. That such variations might be accompanied with changes in the general climate of the earth was a very reasonable supposition, and we cannot be surprised to find the geologists who had started the theory on geological grounds looking hopefully for an explanation of its occurrence in this astronomical law. The objection to the theory was that astronomers of high authority denied the sufficiency of these variations in the shape of the earth's orbit to explain the great changes of climate attributed to them; as, according to their calculations, the same amount of mean heat, if not more, would reach the earth during a period of maximum eccentricity as at other times. This objection to the astronomical theory the authors of the Glacial Theory hoped to remove.

Mr. Croll's ingenious theories furnished a plausible explanation of a connection between changes of climate and these changes in the position of the earth relative to the sun, but the explanation implied an amount of glaciation in both hemispheres of which recent geological research could afford no evidence.

Mr. Croll's theory has been explained by Sir R. Ball in his work entitled "The Cause of an Ice Age." The author shows himself to be a strong believer in the geological theory of the ice age, which is supposed to have occurred in Pleistocene times, but does not pretend to have acquired any personal acquaintance with the facts from which geologists had inferred its occurrence, beyond his observations of ice-scratched rocks in the Kerry Mountains, and an enormous boulder, known as the Cloghvorra stone, which was to be seen lying on one of the slopes of these mountains, and which he considered of sufficient importance to be the subject of the frontispiece to his book.

Being fully convinced of the occurrence of the great northern ice sheet, he undertakes to improve the Geologists' story by giving a graphic and impressive account of the desolation to which the greater part of the Northern Hemisphere was subjected by its passage over it; and then proceeds to state the principles by which its occurrence can be explained by the Astronomical Theory of an Ice Age. He states that, if this ice sheet was the effect of astronomical causes, (1) it must have been an ice sheet covering simultaneously the whole of the Northern Hemisphere down to a low latitude; (2) as it would represent one phase of an alternating sequence of ice periods in the Northern and Southern Hemispheres, during the time that extreme cold was devastating the Northern, a genial climate would be reigning in the Southern Hemisphere; (3) as according to the astronomical law this alternation of cold and warm periods in each hemisphere would have occurred from the time that the earth commenced its revolutions round the sun, both hemispheres must have been subjected to a repetition of ice ages and ice sheets, more or less of the same character as that of the Pleistocene age.

He gives a full explanation of his astronomical theory, which would appear to be much the same as Mr. Croll's, but recognises the difficulty of finding geological evidence to bear out the astronomical theory. In his concluding remarks he writes as follows:—

> "Finally let me say, and perhaps in some degree repeat, what I have urged in regard to the claims of the astronomical theory of the great Ice Age to our acceptance. Geology has taught us by unmistakable evidence that Ice Ages have happened: it is rational to enquire into the causes by which phenomena so startling have been brought about. We find that the astronomical theory affords at once an explanation adequate to the effects which have been observed." (p. 172).

It is clear from this, and other passages, that Sir R. Ball does not profess to attach any further value to his astronomical theory of an Ice Age, than that, assuming the occurrence of the Pleistocene Ice Age to have been unmistakably proved by geological evidence, astronomy would furnish an adequate explanation of the cause.

Those who are inclined to disbelieve in such an occurrence would have their suspicions of its fictitious character confirmed rather than otherwise by Sir R. Ball's little book, while those who are inclined to believe in the geological story, as told by Sir A. Geikie, must need an explanation of the cause as much now as when Sir A. Ramsay first introduced it to the general reader; unless the position it has held so long in geological literature may be supposed to render any such enquiry unnecessary or impertinent.

It is clear from Sir Robert Ball's account of the Astronomical Theory that the ice sheets portrayed in the passages quoted in the previous chapters, vast as they were, were far too limited to satisfy the requirements of that theory.

An ice sheet originating in the mountains of Scotland or Ireland in the west, and extending over the Continent of Europe to Nijni Novgorod or the Timan Mountains in the east, would be only a fragment of the circumpolar ice cap which the astronomical ice age would have produced, if a cause of such cosmic import had had anything to do with its production.

With the familiar knowledge possessed of the polar ice caps, which now cover some 5 to 10 degrees of latitude with permanent ice, it would require no strain of either the imaginative or the reasoning faculties to realise an extension of the polar ice sheet far down into temperate zones, whatever its effect might be on the living occupants of the earth, if we were compelled by indisputable evidence to believe in such an occurrence. But it appears that the ice sheets of the geologists, as described above, are not extensions of any such polar ice sheets, but ice sheets which originated, in part at least, in Scotland or the British Isles, in the middle of an open Atlantic

Ocean. Such ice sheets would appear to be "neither one thing nor the other." They are certainly not the ice sheets of the Astronomical theory, and they would seem to have no raison d'étre *in nature* at all, but to be only conceptions founded on certain geological phenomena to which the glacialist has attached a particular interpretation. A hard frost might explain the covering of a lake with a sheet of ice, but it would not explain the appearance of a patch or two of thick ice in the middle of open water.

PART II.

CHAPTER I.

MR. JUKES-BROWN'S VIEW AS TO THE CAUSE OF OLD GLACIERS IN BRITAIN. DR. GREGORY'S ACCOUNT OF THE GLACIATION OF MOUNT KENYA IN EAST AFRICA.

TO pass from the more orthodox supporters of the story of the Ice Age to writers holding more or less antagonistic opinions on the subject, we will call the readers' attention to the views expressed by Mr. Jukes-Brown in the following passage in his "Handbook of Historical Geology," (1886), as to the character and cause of the old glaciers in Britain.

> "Such physical and geological conditions as these of Britain forming a prolongation of Greenland, washed on both sides by cold Arctic currents, and deprived of the influence of the Gulf stream, would be calculated to produce an extreme amount of cold, and if the evidence of the Glacial period was confined to Britain, would be almost sufficient to account for the facts." (p. 562).

This passage expresses an entirely different theory as to the origin of the old glaciers in this country, to that expressed or implied in the account given by Sir A. Geikie. We are not left in the dark as to the cause, nor are we called upon to believe that the geography of these parts was the same when these glaciers existed as it is now.

Mr. Jukes-Brown infers a former connection with Greenland from the well-known submarine ridge which extends from Scotland to Greenland through Iceland, separating the abyss of the Northern from that of the Atlantic Ocean.

In the detailed account given by Sir A. Geikie in his "Scenery of Scotland"* of the evidence of old glaciers in that country, there is little to show that the glaciation of Scotland in the supposed Glacial period was not explicable, according to the writer's own views, by a difference in the local conditions affecting the climate of that country, were it not for his connecting it with other glacial phenomena in the surrounding seas and lands, which could not be inferred from any amount of glaciers in Scotland, any more than the condition of the ocean and other land surfaces in the neighbourhood of Greenland could be inferred from the extent to which that land area is now glaciated. In connecting the glaciation of Scotland with Ice Sheets filling the North Sea and the Irish Channel, Sir A. Geikie must have had other ground to rely upon than the evidence of glaciers in Scotland and Norway. But it is difficult to imagine a cause, or causes, which would fill the North Sea with ice from floor to surface, and yet leave the Atlantic Ocean open to the north and west, outside the line of permanent ice which extended from Cape Clear in Ireland to the North Cape in Norway. His account of the movement of the glaciers in Scotland, from the high lands in the centre towards the sea, on the north side as well as on the west, (as illustrated by a map), is fully in accordance with the view that however large and abundant, they were no more than local glaciers generated by local conditions; while his representation of the glaciers on the north coast breaking off into icebergs "that probably drifted away to the north" would seem to forbid any connection between the glaciation of Scotland and the ice of the arctic or polar regions; still more any connection with the circumpolar ice sheet of the Astronomical theory.

---

* p.p. 248—252.

To return to Mr. Jukes-Brown's account, we find that while striking a severe blow at the foundations of the Glacial theory, he is sufficiently orthodox to suggest a connection between the glaciation of Britain and the Glacial period. He adds the following to the passage quoted above :—

> "But since similar phenomena occur over all the northern part of Europe, Asia and America, we must admit that the cosmic causes had also much to do with the induction of the Glacial Period."

We cannot take this expression of a pious belief in a story for which he was not responsible as a strong authority for the truth of that story.

We shall not attempt to discuss in these pages the value of the evidence of the Ice Age, which is to be found in glacialist literature, as occurring in the European continent, or in North America, but we will call the reader's attention to some evidence of glaciation in the Tropics, both old and recent, which, while furnishing strong support to the view that the old glaciers in Scotland and elsewhere were due to local conditions, goes far to dispel altogether the belief that the evidence of old glaciers in any part of the world furnishes any support to the story of the Ice Age.

In his explorations in British East Africa in 1893, of which he gives a most interesting account in his book "The Great Rift Valley," Dr. Gregory made a careful geological examination of Mount Kenya, which is situated on the eastern border of "The Great Rift Valley," and he gave an account of the results of his investigation in a paper read before the Geological Society in 1893.*

It is sufficient for our purpose to give his own summary of his conclusions. "Summary of Conclusions," (p. 530):—

> "That by the discovery of moraines, striæ, lake basins, perched blocks and roches moutonnés, below the present limit of the Kenya glaciers, it is proved that these must once have extended for at least 5,400 feet below their present level.
>
> That at the time of maximum glaciation Mount Kenya was covered by a great ice-cap, or "Calotte," and did not merely support a system of valley glaciers.
>
> *That the glaciation was due to the former greater elevation of Mount Kenya, which has been reduced by subsidence and denudation.*
>
> The theory of universal glaciation is unnecessary, and is opposed to many facts in African geology.
>
> That the glaciation affected the adjoining mountains including Kilima Njoro, Ruwenzori, Elgon, and Abyssinia, is rendered highly probable by the facts of botanical distribution. That the meteorological changes concomitant with the maximum glaciation, and also due to the elevation, would have been the foundation of a high pressure area, and an increase in the amount of the rainfall, its more equable seasonal distribution, and a lowering and widening of the surface of maximum rainfall. This would have led to a great change in the distribution of animal and plant life."

---

* See "Geological Journal," May, 1894.

In this account we have all, or nearly all, the phenomena, which appear in the glacialists' repertory as the evidence or characteristic features of ancient glaciers and ice sheets, found in the valleys of a mountain, the higher parts of which are now filled with glaciers,—the mountain being situated on or a little south of the equator, in a position on the earth's surface where it could not be affected by a climatic cause which was supposed to produce an intensification of cold nearer the poles. The facts reported as showing the presence of glaciers in former days in lower parts of the mountain valleys than the present glaciers reach, are interpreted by Dr. Gregory as evidence of larger and more extensive glaciers, due to the greater height of the mountain, and the meteorological conditions, which were the natural accompaniments of such greater elevation.

The higher the mountain, the greater the accumulation of snow on its summits, and the larger and longer the glaciers by which its snow cap is drained, would seem to be an axiom in glacier physics. How far the reduction in the height of Mount Kenya is to be attributed to the mere effect of denudation, or to subsidence, is a question of little importance. If it is a very old mountain, and has not been affected by crust movements, the forces of denudation are probably sufficient to account for the reduction in its height. If it has been subjected to crust movements since its original elevation, a subsidence of a few thousand feet of a mountain 20,000 feet high now, would be only a natural occurrence in an area situated on the edge of the Great Rift Valley, which, according to Dr. Gregory, is in a line of weakness extending throughout Africa, and along which oscillatory movements of considerable extent may be confidently assumed to have taken place at no distant time.

Whatever part the greater elevation of Mount Kenya may have played in the development of a larger snow-cap on the summits, or larger and longer glaciers in the valleys, the greater glaciation of this mountain in former times cannot be attributed to any refrigeration of the general climate of the earth. The records of the old glaciers furnish an instructive example of the production of the characteristic evidence of the supposed Ice Age by means of local conditions, and suggest very forcibly the question—why should not the corresponding occurrences in northern regions admit of the same explanation ?

Dr. Gregory's paper appears to have been read before the Geological Society without being followed by any discussion. In his edition of "The Great Ice Age," published in 1890, Professor J. Geikie introduces a short resumè of Dr. Gregory's conclusions, and offers, in a note, the following criticism on his theory :—

> "*In the short abstract of Dr. Gregory's paper no evidence is given of the former greater elevation of Mount Kenya than that supposed to be furnished by the glaciation.*
>
> *He would like to know what are the many facts of African geology which are opposed to the view that the snow line may have been depressed generally. A lowering of the temperature a very few degrees, with increased precipitation, is probably all that would be required to bring back the old calotte to Mount Kenya.*"

This is a very feeble defence to what was evidently a powerful blow at the foundation of the story to which he had affixed the title of "The Great Ice Age."

No geologist, or any student of geology who had taken in the first principles of the science, could require evidence of the lowering of a mountain by denudation, which was supposed to have been in existence in early Pleistocene times, unless he was compelled to ignore these principles in the necessary assumption of the glacialists that the conditions of every area furnishing evidence of the Glacial period, was "practically" the same as it is now.

In his requisition for "evidence in African Geology" against a supposition that the *snow line may have been depressed generally*, he can only be asking for evidence against the inference of the early glacialists, that the refrigeration of the glacial period extended to the tropics. It was the attempt of Agassiz and Belt to prove the extension of the Northern Ice Sheets into the tropics that first brought ridicule on the theory, while the adoption of Mr. Croll's theory excluded the supposition that the cold of a glacial period in either hemisphere could affect parts near the equator. As Mount Kenya lies slightly south of the equator, it would be under the influence of the increased heat which affected the southern hemisphere, while the glacial period was reigning in the north.

CHAPTER II.

"BOULDER-CLAY"—AGASSIZ' ACCOUNT OF THE DRIFT DEPOSITS OF SOUTH AMERICA.

IN Dr. Gregory's account of the evidence of the old glacier in Mount Kenya, he only notices shortly the discovery of "boulder-clay." He tells us, however, that near the well-preserved remains of the old moraine:—

> "Small sections cut by streams show that these occurred in a stiff, greasy clay, formed of a redeposited volcanic ash. It was of the familiar type of the matrix of the boulder-clay."

The discovery of clay of the familiar type of boulder-clay, as the product of an old glacier in the tropics, would in earlier days have been welcomed by the glacialists as a good witness on their side in their controversy with the diluvialists, in which both parties relied on the boulder-clay deposits as the main foundation of their very antagonistic theories.

In an article in the "Quarterly Review" (October, 1863), relating to the Glacial theory when first brought before the public, is the following passage:—

> "All examples of human reliquiæ are admitted to have been of later date than *the boulder-clay, which in Northern zones is the most characteristic member of the deposits formerly called Diluvial but now Glacial.*
>
> They are now called "glacial," and are believed to have been accumulated under the influence of a degree of cold greater than now prevails in Northern Zones. During that period glaciers occupied the mountains of Britain, and icebergs are believed to have floated on the waters which flowed several hundred feet deep over the lower levels. On the whole we must regard the glacial problem in its geological aspect as yet but imperfectly solved."

It is very clear from the discussions on the Glacial theory in these early days that it was generally recognised as a substitute for the Diluvial theory. As to the very important part played by the "boulder-clay" in the foundation and development of the Glacial theory, the following passage from Professor J. Geikie's second edition of "The Great Ice Age," 1873, is very significant.

> "I do not suppose that there is anyone nowadays who has given the matter the slightest consideration without coming to a firm belief in the ice origin of boulder-clay. But as regards the precise way in which this striking deposit owes its origin to ice there is still some dispute." (p. 25).

In 1894 Professor Geikie published another edition of this work, in which he makes the following statement as to the belief which geologists had then arrived at with regard to boulder-clay:—

> "*All are agreed that it is a product of ice action, but how or in what way it owes its origin to that action appears to be still more or less a mystery to some.*" "Great Ice Age," 3rd edition (p. 28).

These are very tell-tale passages. Both involve an admission or imputation that the belief that "boulder-clay" was the product of ice action, was accepted by geologists before its connection with glaciers or ice-sheets had been ascertained. Is there any parallel to this in the history of science?

The importance of the matter arises from the fact that it is evident from the history of the origin of the glacial theory that this article of belief is the fundamental dogma on which the whole story as a geological theory rests.

It was essential to the original object and conception of the theory, that the "Diluvial" deposits, of which at that time no cause had been ascertained as a substitute for the Noachian deluge, should be accepted as being the product of ice action.

That "boulder-clay" when found in glacier valleys, whether old or recent, is to some extent the product of glaciers, is indisputable, however much the part taken by ice in its production, either now or in former times, might be open to question. The reason why geologists have found a difficulty in determining clay deposits found in the Drift to be "glacial boulder-clay" is not far to seek. The dogma has been founded upon an utterly unwarrantable assumption, that "boulder-clay" as a glacial product can be distinguished from "boulder-clay" as the product of rivers and floods or other water action. The material of which both are composed being the same, viz., the material eroded from the rocks over which a glacier or a river flows, and the instruments by which the erosion is effected being also the same, viz., the stones, gravel and sand which are pressed against the rocks underlying or forming the sides of the river or glacier, there can be no intrinsic difference in the two products.

That there can be nothing in the boulder-clay itself to prove whether it was produced by flowing water or ice, is very clearly shown by by Sir A. Geikie himself in passages connected with his explanations of the general principles of Geology.

In his "Scenery of Scotland," already referred to, we find the following passage in a part dealing with the effects of rivers in carving out the surface of a country :—

> "Much may be learnt in such a dingle regarding the action of rivers in hollowing out their channels. In not a few places, for instance, round well-worn basins may be noticed in the rocks forming the bed of the stream. During dry summer weather, when the brooks are low, these basins or potholes may be easily examined. Each of them will be found to have its bottom covered with smooth polished stones and gravel, and its sides will be equally worn. The activity of the stream is then almost at zero, and we can hardly perhaps imagine how such circular cavities could have been scoured out of the solid rock. *But let anyone visit the same scene when the stream in flood comes roaring down the rocky gorge, sweeping along its burden of mud, sand, gravel, and stones; when the boulders may be heard striking against each other as the torrents thrust them forward, and when in a few hours many tons of detritus are carried down and pushed along the bottom and sides of the channel, he will then better understand what a powerful grinding mill the stream at its full flood must be.*" "Scenery of Scotland" (p. 29).

No more precise or complete account of the erosion of rocks, and the production of boulder-clay by torrents and floods could be needed than this to satisfy the requirements of the "Diluvial" theory.

In the article "Geology" already referred to, the same writer explains the action of rivers in excavating their channels, and writes:—

> "In those parts of a river channel where the current is strong enough to keep gravel and boulders moving along, the loose materials cut down the rocky bottom over which they are driven, while there is a general abrasion of the whole bottom over which the loose detritus is rolled. The erosion goes on most briskly in the numerous hollows and grooves along which chiefly these loose materials travel."

That there can be no difference in the boulder-clay produced by rivers and that produced by ice, appears very clearly from a comparison of this passage, with the following description in the same article, of the erosive action of glaciers.

> "The manner in which glacier ice erodes its channel differs in many respects from that in use by any other geological agent, and forms therefore one of the distinguishing features of ice action.
>
> The erosion is effected not by the mere contact and pressure of ice. It is by means of the fine sand, stones, and blocks of rock, which fall between the ice and the rocks on which it moves, that the grinding work of the glacier is done. These materials held in it, as it creeps along, are pressed against the rocky sides and bottom of the valley, so as to descend into each little hollow and mount over every ridge. As a result, the most compact resisting rocks are ground down, smoothed, polished, and striated."

Whatever may have been the object or meaning of the statement that "*the manner in which glacier ice erodes its channel, differs in many respects from that in use by any other geological agent, and forms therefore one of the distinguishing features of ice action,*" it is clear that if the account of the process and effect of erosion in these several passages is correct, there can be no difference in the products of water and ice action. It is equally clear that the supposition that there is a difference in the two products is essential to a theory which would substitute ice for water as the cause of parts of the well known and wide spread "diluvial" drift.

As to the so-called "striation" of rocks—the scratches and grooves in rocks in a mountain valley (like those so well-preserved in the Pass of Llanberis, when covered with turf), may safely be attributed to glacial action, but the above passages certainly furnish no support for the opinion that there could be any such distinctive character in scratches or grooves produced by sharp-edged boulders pushed over rocks by ice, as to prove that these phenomena, when exhibited in ancient rocks in lowland areas, were produced by moving ice rather than by moving water.

Notwithstanding this express recognition and demonstration of the impossibility of distinguishing the effect of torrential from that of glacier action in the production of "boulder-clay," the same writer gives the following account of the origin of the story of the Ice Age, in which he credits the glacialists with having found out the ice origin of the "Diluvial" deposits.

> "Away from the mountains, in such flat parts as Caithness, the shores of the Moray Firth, and of its tributary inlets, and the low land bordering the North Sea, the solid rocks are to a large extent covered with a stiff clay full of stones varying in size up to boulders a yard or more in diameter. To this deposit the name of "boulder-clay" or "till" has been given. It attains its chief development in the great Midland Valley; hence perhaps its detailed description may be deferred until the surface of that region comes before us for examination. *Its origin was long involved in mystery, and, though now more clearly understood, still presents difficulties which have not yet been completely explained. The older geologists called it "diluvial," and regarded it as a proof of a violent flood or series of floods which, sweeping across the country, produced the striation of the rocks by driving over them with stones, sand and clay, which now form the till. The introduction of land ice into the list of agencies concerned in changing the surface of the country gave the true history of this remarkable superficial deposit. Its internal structure and its striated stones show it to be the debris of the abrasion of an Ice Sheet.*" "Scenery of Scotland" (p. 255).

In this passage Sir A. Geikie expressly identifies the "boulder-clay" with the Drift clay, which the older geologists called "Diluvial," and claims that the introduction of the theory of land ice, as an agent in its production, gave the clue to "the true history of this remarkable superficial deposit," while at the same time he admits that "its origin was long involved in mystery, and *though now more clearly understood, still presents difficulties which have not yet been completely explained*."

But the immediate cause of the boulder-clay was never a mystery to the Diluvialists; the mystery with them was the cause of the floods by which it was so evidently produced and spread about.

The unsolved mystery is with the Glacialists in their attempt to explain a *part* of these world-wide deposits by ice action. As to the ulterior cause, the glacialist, without Mr. Croll, is no better off than the Diluvialist without the miraculous story of the flood. To call the time when the ice-sheets are supposed to have occurred, the "Glacial Period" is no more an explanation of the cause of their occurrence than to call the time when the supposed deluges occurred the "Diluvial Period."

It was owing to the absence of any difference between water-made and ice-made "boulder-clay" that the logical Agassiz earned the reputation of being "glacier-mad," by identifying the "drift" deposits of the Amazonian valley in South America as a true glacial boulder-clay, with which he was so well acquainted in Scotland and North America.

We are told by Sir A. Ramsay that it was Agassiz who "led geologists" in forming a belief in the great Northern Ice Sheets.*

Confident in the soundness of a theory which had met with the acceptance of some of our leading geologists, Agassiz reasoned that the great ice sheets which had attained such stupendous dimensions far down into temperate latitudes must have extended to the tropics, and in 1865 he set out with Madame Agassiz on a journey to South America—to search for evidence which would bear out his very logical anticipations.

It was not long before they found what he wanted. In a letter to Professor Pierce, dated the 5th May, 1865, he writes :—

> "Yesterday was one of the happiest days of my life, and I want to share it with you. Here I am at Tijuca, a cluster of hills about 1800 feet high, and some seven or eight miles from Rio, in a charming cottage-like hotel, from the terrace of which is seen a *drift hill with innumerable erratic boulders as characteristic as any I have seen in England.* I had seen before sundry unmistakable traces of Drift, but there was everywhere connected with the drift such an amount of decomposed rocks of various kinds that though I could see the drift and distinguish it from the decomposed primary rocks in places, on account of familiarity with this kind of deposit, yet I could probably never have satisfied anybody else

---

* See Ramsay's "Phys. Geol. and Geog. of Great Britain" (p. 147).

> that there is here an equivalent of the Northern Drift, had I not found yesterday near Bennett's Hotel, at Tijuca, the most palpable superposition of drift and decomposed rocks with a distinct line of demarcation between them." Howorth's "Glacial Nightmare" (p. 264).

He goes on to state that "this drift" is full of various kinds of boulders of different dimensions—

> "I have not traced these boulders to their origin, but the majority consist of a kind of greenstone composed of an equal amount of greenish black hornblend and felspar. Beside this drift, I have not seen any trace of glacial action properly so called, if polished surfaces and scratches and furrows are especially considered as such."

After having continued his investigations over a large part of the Amazonian valley, he gives an account of his researches, and the following statement of his conclusions :—

> "Such are the facts. The question now arises, How were these vast deposits formed?"

He rejects the theory of their having been accumulated when this area was beneath the sea, for the reason that :—

> "The deposits show no sign whatever of a marine origin. It is my opinion that all these deposits belong to the Ice Period in earlier or later phases, and to this cosmic winter, which judging from all the phenomena connected with it, may have lasted for thousands of centuries, we must look for the key to the geological history of the Amazonian Valley. I am aware that this suggestion may appear extravagant. But is it after all so improbable that while Central Europe was covered with ice several thousands of feet thick, when the glaciers of Great Britain ploughed into the sea, and when those of the Swiss Mountains had ten times their present altitude, when every lake in Northern Italy was filled with ice, and their frozen masses extended even into Northern Africa, when a sheet of ice reaching nearly to the summit of Mount Washington in the White Mountains, (that is, having a thickness of nearly 6,000 feet), moved over the continent of North America, is it so improbable that at this period of universal cold the valley of the Amazon also had its glacier poured down into it from the accumulation of snow in the Cordilleras; and swollen laterally by the contributing glaciers descending from the table land of Guiaca? The movement of this immense glacier would be eastward, and determined as well by the reservoir of snow in the Andes as by the direction of the valley itself."

He afterwards paid a visit to the part of the continent south of the equator, to Patagonia and the southern extremity of the chain of the Andes. He found an abundance of ancient drift and of modern glaciers in these parts, but instead of being satisfied with Darwin's view that the drift deposits were nothing else than the detritus of the rising Andes washed down over the lower plateaus, Agassiz could only see in these deposits evidence of the presence of another large ice sheet extending in a northern direction from the Straits of Magellan to somewhere approaching the equator.

He thus states the results of his observations in these two parts of the continent :—

> " During that period two vast sheets of ice stretched from the Northern pole southward, and from the Southern pole northward, extending in each case far towards the equator, and ice fields such as now spread over the Arctics, covered a great part of the temperate Zones." "Glacial Nightmare" (p. 263). "Nature," Vol. vi. (p. 727).

Many persons thought these conclusions of Agassiz a reductio ad absurdum of the theory of great ice sheets in temperate latitudes, if not of the whole glacial theory.

It seems now at all events very strange that Agassiz himself did not suspect some flaw in the premises which had driven him to such marvellous conclusions.

His belief in the enormous depth of the ice sheets in temperate zones was evidently founded on the fallacy that the markings in the upper part of old glacier valleys, whatever might be their depth, were evidence of a glacier having at one time filled them from bottom to top. The same fallacy seems to have been adopted in estimating the depth of the great Northern Ice Sheets described in the passages quoted in the first part of this treatise.

The following passage from a paper by Professor Tyndall, an Alpine climber as well as a great scientist, furnishes high authority for a very different explanation.

> " That such an agent (as glaciers) was competent to plough out the Alpine valleys cannot, I think, be doubted. That the glaciers were the real excavators cannot, I think, be doubted. This view will, I think, carry us still further. *According to it, a glacier is self destructive. Elevations of the land, which would naturally accompany the gradual cooling of the earth, are quite sufficient to account for a glacial epoch ; and the ice itself, in the absence of any other agency, would be competent to destroy the conditions which gave it birth.*" Phil. Magazine, 4th Series, Vol. xxiv. (p. 172), on 'The Conformation of the Alps,' cited in "Glacial Nightmare" (p. 607).

The valley of the Colorado has been excavated to the depth of a mile by the river which is now flowing along its bottom. There would be just as much reason for supposing that at one time this river was a mile deep, as that a glacier in a valley in the White Mountains in North America, or in Switzerland, was once 6,000 feet thick, because glacial markings are to be seen on its rocky sides at that height above its present bed.

As to the other phenomena which are claimed by glacialists as evidence of ice sheets, the "erratics," the "roches moutonneés," the "perched blocks," and the "moraines, "kames" or "asar"; whether ice has taken any part or not in their production or movement, they can contribute no support to the theory of ice sheets, as distinguished from the theory of local glaciers and floating ice.

In identifying the "glacial" boulder-clay with the diluvial drift in the passage quoted above, from "The Scenery of Scotland," Sir A. Geikie admits the origin and object of the Glacial theory, but it is clear, that unless his Ice Sheet theory can explain the deposition of the drift in southern and tropical, as well as in northern regions, the Glacial theory, as explained by him, would furnish an explanation of a very small portion of the "diluvial" drift.

CHAPTER III.

DR. BUCKLAND'S ACCOUNT OF THE DILUVIAL DRIFT.—HIS ANTICIPATIONS IN 1841 AS TO THE END OF THE GLACIAL CONTROVERSY.—EVOLUTION OF THE GLACIAL THEORY.

THE following account of the boulder-clay deposits of England and Germany (which the glacialists appropriated as the special product of ice), is given by Dr. Buckland in the treatise already referred to. It is remarkable for its corresponding so closely, in its details, with the glacialists' own account of the same deposits as exhibited in the same area.

> "The loam itself possesses no character by which it is easy to ascertain the source from which it has been derived, but usually varies with the nature of the hills composing the adjacent districts. It is of immense extent on the continent; is known in Germany by the appellation of "Dammerde," and of "Terrain d' attrissement" in France..........
>
> Now if we examine, with this view, the eastern coast of England, we shall find that from the mouth of the Tweed to that of the Thames, it is covered irregularly with beds of superficial loams and clay and gravel, of enormous thickness, not only in the lowland districts, but also on the summit of lofty hills, and on elevated table lands of the interior..........
>
> They abound still further on the shores of Norfolk, Suffolk, and Essex, forming along the coast cliffs that overhang the sea, and are undergoing a perpetual destruction by the sea. In the interior they are spread widely over the table lands of Suffolk and Norfolk. Their most common character in the localities here enumerated is that of a tough bluish clay, through which are interspersed irregularly pebbles of various kinds, together with the bones of elephants and other animals before spoken of. The pebbles are of two classes: (1) composed of the wreck of the adjacent inland districts of England; (2) large blocks and pebbles of many varieties of primitive and transition rocks, which do not occur in England, and which can only be accounted for by supposing them to have been drifted from the nearest continental strata of Norway by a force of water analogous to and contemporaneous with that which drifted the blocks of Finland granite over the plains of Russia and the North of Germany. A diluvial current from the north is the only adequate cause that can be proposed, and it is one that seems to satisfy all the conditions of our problem." (p. 191).

However unreasonable the theory of a universal deluge of water might be to explain the drift deposits, the substitution of a deluge of ice, of similar extent and depth, would certainly not have furnished a more reasonable or credible explanation, if it had not been supposed to be supported by the astronomical theory we have previously noticed.

Some years after the publication of this treatise, Dr. Buckland abandoned his view as to the universal deluge and fell in with the views of Agassiz as to the evidence of ancient glaciers in Scotland. In his anniversary address as President of the Geological Society in 1841, he expressed his anticipations with respect to the Glacial controversy in the following passage:—

> "It will probably be settled, as in most cases of extreme opinions and exclusive theories, by a compromise. The glacialist will probably abandon his universal covering of ice and snow, and be content with glaciers in the elevated regions of more southern latitudes than now allowed of their formation; the diluvialist, still retaining his floating ice-bergs as the most efficient agent in the transport of drift and erratic blocks to regions distant from their place of origin, may also allow to glaciers their due share in the formation of moraines and striated surfaces in latitudes and at an elevation that are no longer within the zones of perpetual congelation."

The terms of Dr. Buckland's anticipated compromise would seem to be very much in accord with the views intended to be expressed in these pages.

We now see the logical process by which the "Story of the Ice Age," as told in the passages cited in the first part of this treatise, was evolved.

Assuming that the "boulder-clay" of the Scotch valleys and other mountainous regions, was the product of glaciers, it was clear that such a cause of its production could not apply to all the wide spread drift deposits found in almost every country in the South as well as the North.

This objection appears to have been got over by suppressing the original object of the Glacial theory and limiting the range of "boulder-clay" as a glacial production, to the northern parts of the Northern Hemisphere. Within this limited area "boulder-clay" was not only claimed as the product of ice, but it was actually put forward as the evidence of the great ice sheets, whatever the cause of its production might be when found beyond the limits placed by glacialists to their extension, and however indistinguishable it might be from "boulder-clay" produced by fluviatile action.

But again, assuming that "boulder-clay" in northern regions was the product of ice, local glaciers and ice-bergs were evidently not sufficient to explain the distribution of this deposit in wide lowland areas, where, in fact, it is found in greater abundance than in mountain valleys. Large ice sheets could alone explain the wide spread of this deposit. Hence the conception of the great Northern Ice Sheets.

But large ice sheets could not be produced without the prevalence, during a long period, of much greater cold than that of the present day. Hence the conception of a Glacial Period.

But the occurrence of such a period with its great ice sheets, continued during a prolonged lapse of time, was inconsistent with the evidence furnished by the Drift itself, even in Scotland, that life was not extinguished during its continuance. Hence the conception of the Interglacial Periods.

When the theory was issued to the public, the logical sequence by which these several conceptions were evolved was reversed. The Glacial period is given a position as an historical event beyond the reach of criticism, while the subsidiary conceptions or inventions on which it was founded are put forward as the effects of its occurrence and illustrations of its truth.

It followed from this mode of introducing the theory that the controversies, which the paradoxical and startling story induced, were confined to the discussion of its alleged effects, more especially the very disputable dogma that "boulder-clay" was a glacial production.

CHAPTER IV.

MR. H. B. WOODWARD'S VIEW AS TO DEPOSITS OF THE GLACIAL AGE.—GLACIAL NOMENCLATURE.—DR. MURRAY'S THEORY OF A "GLACIAL" AND A "DILUVIAL" PERIOD.

THAT the occurrence of a glacial period of some kind in the Pleistocene Age should acquire a firm footing in Geological science, while the foundations on which it was built by its original inventors were one and all subjects of controversy, is probably to be explained by the fact that Lyell himself believed in tne occurrence of a general change of climate, from a warmer to a much colder temperature at the time of the "so-called Glacial Period," as he sometimes expresses it, while he regarded the ice-bergs, to which he, with the diluvialists, attributed the distribution of erratics over certain areas, as the effects of such colder climate. Hence the controversy which followed the promulgation of the story of the Glacial Period was mainly confined to the subordinate question whether icebergs or land-sheets produced the "boulder-clay;"—the occurrence of a cold period of some kind being assumed by both combatants as a common ground.

Hence also we find geologists who held very different, and even directly antagonistic views, on what were in fact fundamental doctrines, treating them as subordinate problems still under investigation, or as extravagancies which could be rejected entirely, without calling in question the occurrence of a glacial age, as an historical event, of some kind.

Thus we find that Mr. H. B. Woodward, when introducing his account of the "Glacial Period" in his "Geology of England and Wales," assumes the "Glacial Period" as a period in geological chronology, and proceeds to give an account of what he calls "glacial Deposits." But he at once explains that by "Glacial deposits" he means no more than "deposits of Glacial age." "*The Glacial deposits*," he says, "*or rather the* *deposits of Glacial age, include gravel, sand, loams and clays.*" As "gravels, sand, loams and clays," if ever the products of ice, must have been in Mr. Woodward's opinion the product of water action, as well as of ice, it would follow that he would not be any way challenging the occurrence of the "Glacial period" in attributing all the particular deposits which he records as "glacial" to the action of flowing water. Treating the Glacial Age merely as a chronological period, he proceeds to subdivide it into Lower, Middle, and Upper Glacial, in accordance with a system of classification adopted by the glacialist authorities.

This mode of treating the subject seems to have been generally followed by stratigraphists, independent altogether of any views they may have formed as to there being any connection between the particular deposits they might be treating and ice action. This practice, while it has given the stratigraphist a free hand in treating the Pleistocene drift deposits, has acted most powerfully in maintaining the credit of the "glacial period" as an historical occurrence, while its foundations have been gradually more and more undermined by the very persons who, in using the glacial nomenclature, have added the weight of their authority to a story which some of them at all events may not have believed in at all.

Some late writers who have approached the question of the drift without any intention of calling in question the existence of a glacial period, when dealing with certain drift deposits which, although occurring in Pleistocene times, were in their opinion the effect of water action and not ice, have found a happy mode of reconciling their views with the orthodox creed by attributing them to the effect of the floods and torrents which were caused by the melting of the great ice sheets or glaciers at the close of the supposed glacial period.

We find this course carried out in its fullest extent in the following passage from Dr. Murray's article on "Archæology" in the last edition of the "Encyclopædia Britannica."

In the first part of this passage he gave an account of the glacial period, in accordance with the general theory as to its effects on animal and vegetable life, but in ignoring the great northern ice sheets and representing enormous glaciers connected with mountain ranges in France and elsewhere as its effects, his views as to the character of the glaciation of the period, would seem to be strongly inclined to the theory of local glaciers developed by local conditions. In the latter part, however, he throws over altogether the glacialist theory as to the cause of the drift deposits, and attributes them to the floods caused by the melting of the glaciers at the close of the glacial period, during a succeeding 'diluvial' period, and he identifies the drift deposited during this period with that which had until recently been referred to the Noachian deluge.

> "After some slight modifications of this low temperature, and a consequent advance and retrocession of the glacial influences in France and elsewhere, along what was then the border lines of a north temperate zone, the Glacial Period draws to a close. A gradual and persistent rise of temperate carried the lines of ice and perpetual snow further and further northwards, except in the regions of great elevation, as in the Swiss Alps. *This was necessarily accompanied by the melting of the vast glaciers accumulated in the mountain valleys throughout the long period of cold. The broken rocks and soil of the highlands were swept into the valleys by torrents of melted ice and snow. The lower valleys were hollowed out, and reformed under this novel agent, and the landscape received its present outline of valley, estuary and river bed, from the changes wrought in the Diluvial epoch. The enormous power of the torrents thus acting continuously through a period of prolonged duration, and the vast deposits of sand, gravel, and clay, with the embedded remains of contemporaneous animal and vegetable life, which, while they everywhere covered the plains, were viewed until recently solely in relation to the Mosaic narrative of a universal deluge, and were referred implicitly to that cause.*"

But we have seen in the passage quoted above from Sir A. Geikie's "Scenery of Scotland," that this authoritative exponent of the Story of the Ice Age had expressly claimed these deposits as the product of the great ice sheets when in their full vigour and advancing movement. In this mode of varying the story, Dr. Murray has harmonised two directly antagonistic theories, by adopting them both. Had he been fully aware of the origin of the story of the Ice Age, as a substitute for the Diluvial theory, he could hardly have enriched his article by introducing both a "Glacial Period" and a "Diluvial Period" as Archæological facts.

PART III.

CHAPTER I.

CRUST MOVEMENTS—DUE TO THE CONTRACTION OF THE EARTH.—SIR A. GEIKIE'S EXPOSITION OF THE THE THEORY.—THE EFFECTS OF LATERAL PRESSURE ON THE SURFACE OF LAND AREAS.

IF the wide spread drift and boulder-clay deposits of South America are no evidence of ice sheets, they bear ample evidence of the enormous extent over which the detritus of a mountain range can be spread in a long course of time, when it is not washed away by subsequent submergence, or carried off by an established river system to form deltas in the sea.

The principles of geological dynamics have undergone an important change during recent years in the theory of crust movements. That in Palaeozoic periods the crust of the earth was subjected to oscillatory movements which repeatedly altered the areas of land and sea, and that these movements continued to operate with diminished intensity during later geological periods, was a well established scientific doctrine, but as to the cause of these movements, opinions were diverse and unsettled, and no theory identifying the cause of the elevation and depression of land areas with that of the origin of mountains had met with general acceptance until the latter part of the last century.

According to the Dynamic principles taught by Lyell, all movements of the crust were due to disturbances of an igneous nature occurring deep down in the interior of the earth, giving rise to a force acting vertically upon the crust, and causing large areas of surface to rise and sink, without necessarily involving much, if any, disturbance or dislocation in the surface strata composing the part of the crust thus affected.

The theory that the principal cause of crust movements was the contraction of the earth during cooling, independent altogether of any disturbing effects from igneous forces, although advocated by De la Beche and a few other geologists, was little known in Lyell's days, and was not accepted by him,* although his own views as to the causes of earth movements did not restrict in any degree his belief in the extent or frequency of movements of elevation and depression, affecting large areas of land and sea, during very recent geological times.

The passage in Sir A. Geikie's article in the "Encyclopædia Britannica," to which we have already referred, contains a full and precise exposition of this theory, as now understood and adopted by geologists.

The following extract will sufficiently explain the principle for the purpose of our argument. After referring to the effect of igneous causes in disturbing the crust of the earth, he says:—

> "A far more important and generally effective cause is to be sought in the secular contraction of the globe. If our planet has been steadily losing heat by radiation in space, it must have proportionally diminished in volume. The cooling implies contraction, but the contraction has not manifested itself uniformly over the whole surface of the planet. The crust varies much in structure, in thermal resistance, and in the position of its iso-thermal lines. As the hotter nucleus contracts more rapidly by cooling than the cooled and hardened crust, the latter must sink down by its own weight, and in so doing requires to accommodate itself to a continually diminishing diameter.
>
> The descent of the crust gives rise to enormous tangential pressure. The rocks are crushed, crumpled, and broken in several places. Subsidence must have been the general rule, but every subsidence would doubtless be accompanied by upheavals of a more limited kind. The direction of these upheaved parts would largely depend upon the original structure of the crust. It would be apt to occur in lines which, once taken as lines of weakness or relief from the intense strain, would probably be made use of again and again at successive paroxysms or more tranquil periods of contraction." "Enc. Brit." Vol. x. (p. 257). See also "Class Book of Geology," chap. xvi.

*See "Principles of Geology," 12th Ed., 1875, (p.p. 236—321).

The doctrine that movements of elevation and depression were due to a vertical force acting simultaneously under large surface areas, would support a view that an area sufficiently large as to include, not only the area of the British Isles, but even a large part of the Northern Hemisphere, would be liable to be raised or depressed simultaneously by the same earth movements. On the other hand, it would be quite consistent with this theory, to consider that a large part of the earth's surface might be free from any disturbances during a long lapse of years. It is clear that such a supposition was necessary to the conception of great ice sheets travelling simultaneously over Europe and America, and leaving behind them, on a still existing surface, evidence of their presence. Such a view would be essential to the conception of a glacial period, which was supposed to have been proved by geological evidence. Nor would the theory of the production of crust movements by a vertical force furnish any satisfactory explanation of the small local squeezings and dislocations, so often met with, even in the uppermost and latest deposits, as it would not involve any violent disturbance of the crust itself during the process of elevation and depression. This process of reasoning is entirely displaced by the Contraction theory. It is a direct inference from this principle that the upper strata of the crust are ever subjected to a great lateral pressure, liable to be increased enormously at different times and different places, as the process of settlement proceeds; and that this pressure acts upon and through every particle of the material of which the upper crust is composed, producing ridge and furrow undulations of its surface, as shown by the hills and dales in a lowland country, as well as by the parallel ranges in a mountainous area.

But this theory, while explaining the elevation and depression of surface areas, does not admit of a large area being affected in the same manner at the same time. It rather implies that the movement is of an undulatory character, and that the same force of lateral pressure, while raising the surface at one part, would be depressing it at another, at no great distance, at the same time ; while it would be directly contrary to the mode in which these large effects were produced by lateral pressure, to suppose that they could occur without a considerable amount of distortion and dislocation taking place in the strata of which the upper layers of the crusts were composed.

But the greatest value and importance of the Contraction theory is that it supplies a simple and complete explanation of the origin of the drift deposits, wherever they are to be found, in the north or south, in islands or continents, in Scotland or South America, and renders it unnecessary to call in any abnormal and exceptional occurrence as either a universal deluge or a glacial period to account for them. According to the Contraction theory, the drift deposits would be the effect of the disturbance of the surface, incident to the elevation of every terrestrial area, while subject to the incessant operation of the aerial denuding forces ; such effects being more abundantly exhibited in areas in which the elevatory movement produced mountain ranges, or districts of high land.

CHAPTER II.

DARWIN AND LYELL.—MOUNTAIN DETRITUS IN SOUTH AMERICA. — DILUVIAL AND ALLUVIAL DEPOSITS.—THE FLOOD AND THE "GLACIAL" DRIFT.

TO recognise the effects of the elevation of land areas, and the forces of subaerial denudation in producing the superficial deposits known as "The Drift," we have only to contemplate the effects of a continuance of their joint operation during many thousands of years on the surface of a land area, comprising a mountainous district, in which the elevating movement was continued in great intensity after it had either ceased to disturb, or was only slightly affecting, the lowland areas around it. The following passages from Darwin and Lyell will furnish ample information and illustration of these effects, as exhibited in the plateaus of South America by the same deposits which Agassiz had confidently determined to be the products of large ice sheets. The readers of Darwin's Journal of "A Voyage round the World" are familiar with the effects of subaerial denudation exhibited in the Andes and mountain ranges in which the process of elevation has been going on with great activity during recent years. He tells us that at Port St. Julian, in Patagonia, he noticed a vast deposit of shingle which reached from the east coast to the foot of the Cordillera.

> "It probably everywhere extends to this great chain, whence the rounded pebbles of porphyry have been derived. We may consider its average breadth 200 miles, and its average thickness as 50 feet. If this great bed of pebbles, including the mud necessarily derived from their attrition, was piled into a mound it would form a great mountain chain. Chap. viii. (p. 123).

> No one fact in the Geology of South America interested me more than these terraces of rudely stratified shingle. They precisely resemble, in composition, the matter which the torrents in each valley would deposit, if they were checked in their course by any cause such as entering a lake, or arm of the sea. But the torrents, instead of depositing matter, are now steadily at work wearing away both the solid rocks and these alluvial deposits along the line of every main and side valley. It is impossible here to give the reasons, but I am convinced that the shingle terraces were accumulated during the gradual elevation of the Cordillera by the torrents delivering, at successive levels, their detritus on the beach-heads of long narrow arms of the sea, first high up in the valleys, then lower and lower down as the land rose." Chap. xv. (p. 229).

His idea of the period in a mountain's history, when the secular process of denudation began to destroy it, may be gathered from his observation, that the Andes, when first rising, were no higher than Snowdon or the Grampian ranges. He might have said—than the Chiltern or Cotswold Hills.

In his "Principles of Geology," Lyell gives the following view of the origin of the drift in the Amazonian valley :—

> "In order to explain the great Amazonian formation above described, Professor Agassiz conceives that the whole valley was for a long time converted into a lake by a large dam or barrier stretching across its seaward extremity, and which has since been removed by the ocean. A similar hypothesis has been advanced again and again to account for the vast extent of old fluatile and lacustrine deposits, as well as for the *inundation-mud called loess*, which once filled the lower portions of the basins of most of the principal rivers of the world, such as the Mississippi, Nile, Danube, and Rhine. I have elsewhere endeavoured to show that such phenomena are the natural result of oscillations in the level of the land extending over large continental areas, by which the fall of the rivers is lessened at certain periods, giving rise to accumulations of matter more or less lacustrine, while subsequently, when a movement takes place in an opposite direction, the rivers cut through their old deposits, excavating the valleys, and often eroding them below their original depth. There is nothing new, therefore, in the character of the Amazonian clays, sands and loess, so far at least as they are of recent or post-tertiary date, except the gigantic scale on which they have been developed.
>
> Professor Agassiz has hazarded the startling conjecture that the Amazonian basin was closed up and converted into a lake by the terminal moraine of a glacier, which stretched thousands of miles from west to east and entered the sea under the equator. But this distinguished naturalist candidly confesses that he failed to discover any of these proofs which we are accustomed to regard, even in temperate latitudes, as essential to the establishment of the former existence of glaciers where they are now no more. "Principles of Geology," 12th Ed., Vol. I. (p. 465—6).

These passages from Lyell appear in a section treating of "The Reproductive Effects of Rivers." The illustrations he gives are the effects produced by rivers now existing in different continents, which are the main drains of the system by which the waste of land and mountains in the interior, under the process of subaerial denudation, is now carried down to form deltas in the sea. He also shows how deep and wide-spread deposits of clay and gravel have been produced in some countries by earth movements occurring in historic times, which have disturbed the levels of the land surface over which these rivers flow.

We need not seek for more information than that furnished by his Eighteenth and Nineteenth Chapters to enable us to realize what would be the condition of the surface during the period which must have existed in every country, before its present drainage system, with its large rivers, was developed.

We will quote a few passages having a direct bearing on this subject :— Chap. xviii. (p.p. 419—421).

> "The Po affords an instructive example of the manner in which a great river bears down to the sea the matter poured into it by a multitude of tributaries descending from lofty mountains. It has been calculated by Mr. Geikie that the river removes one foot of rock from the general surface of its basin in 729 years. The changes gradually effected in the great plain of Northern Italy since the time of the Roman Republic are considerable. Extensive lakes and marshes have been gradually filled up, as those near Placentia, Parma, snd Cremona, and many have been drained naturally by the deepening of the beds of the rivers. Deserted river courses are not infrequent, as that of the Serio Morto, which formerly fell into the Adda, in Lombardy. The Po also itself has often deviated from its course, having after the year 1390 deserted part of the territory of Cremona and invaded that of Parma, its old channel being still recognisable and bearing the name of Po Morto. There is also an old channel of the Po in the territory of Parma called Po Vecchio, which was abandoned in the 12th century, when a great number of towns were destroyed.
>
> To check these and similar aberrations, a general system of embankment has been adopted, and the Po, Adige, and almost all their tributaries, are confined between high artificial banks. The increased velocity acquired by streams thus closed in enables them to convey a much larger portion of foreign matter to the sea; and consequently the deltas of the Po and Adige have gained far more rapidly on the Adriatic since the practice of embankment became almost universal. But although more sediment is borne to the sea, part of the sand and mud, which in

> the natural state would be spread out by annual inundations over the plain, now subsides in the bottom of river channels, and their capacity being diminished, it is necessary in order to prevent inundations in the following spring, to extract matter from the bed and add it to the banks of the river. Hence it appears that these streams now traverse the plains on the top of high mounds like the waters of aqeducts, and at Ferrara the surface of the Po has become more elevated than the roofs of houses.

As to the effect of confining the waters of this area to the river Po in increasing the deltas at its outfall, he states that :—

> "Adria (a town near its mouth) was a seaport in the time of Augustus ; it is now about twenty miles inland."

He further writes :—

> "Although so many rivers are rapidly converting the Adriatic into land, it appears by the observations of M. Morlot, that since the time of the Romans there has been a general subsidence of the coast and bed of the sea in the same region to the amount of five feet, so that the advance of the newly made land has not been so fast as it would have been had the level of the coast been unaltered."

As to the normal action of annual floods, in his account of the Mississipi, he says :— Chap. xix. (p. 440).

> "It has been said of a mountain torrent that it lays down what it will remove, and removes what it has laid down, and in like manner the Mississippi, by the continual shifting of its course, sweeps away, during a great portion of the year, considerable tracts of alluvium which were gradually accumulated during former years, and the matter now left during the spring floods will at some future time be removed."

As to the older deposit, which he called "loess," he mentions an exposure of it at Nantchez, on the left bank of the river, appearing in a cliff 200 feet high. (p. 460).

> "The lower part of this cliff consists of gravel and sand, while the uppermost, 60 feet in thickness, is a mass of loam, *exactly resembling the loess of the valley of the Rhine,* without stratification, and full of land shells, such as Helix and Pupa, together with the amphibious genus Succinea, all of species now living in the same country..........
>
> This same loess is continuous over a vast extent of country always extending in thickness near the Mississippi."

In p. 461, he introduces a sketch of exposures of this deposit at Vicksburg, showing its relative position in the cliffs with respect to the "Modern Alluvium" of the Mississippi.

As to the mammalia, of which some bones have been found in the lowest part of the "loess," and in clay at its base, he says:—

> "They are many of them of extinct species, among them are Mastodon Giganteus, a species of Megalonyx, a Mylodon, Bison longifrons, Equus Americanus, Felis Atrox (a large kind of carnivore about the size of a tiger), two species of deer, two of bear, and other quadrupeds, some extinct and some living."

Whether these mammalia may be supposed to have existed in the Pleistocene or any previous biological period, is immaterial to our present subject. It is clear that this mixture of extinct with living species, found in those old deposits, shows that it bears the same relation to the alluvium of the existing Mississipi, as the old drift deposits in this country, which were called "Diluvial" now "Glacial," bear to the alluvial deposits of our present rivers.

He then speaks of the Ganges and the Brahmapootra, and refers to the account given by Major R. H. Colebrooke, of the alteration in the course of the river,—

> "The rapid filling up of its branches, and the excavation of new channels where the number of square miles of soil recovered amounted in one case to 40 square miles in the course of a few years. Great islands have been formed in their channels during a period far short of a man's life. A large tree or a sunken boat is sometimes sufficient to check the current and cause a deposit of sand, which accumulates until it usurps a considerable portion of the channel.
>
> It sometimes happens at the season when the periodical flood is at its height that a strong gust of wind, conspiring with a high spring tide, checks the descending current of the river, and gives rise to much destructive inundation.
>
> The populations of all oceanic deltas are peculiarly liable to such catastrophes, and we may safely assume that such tragical events have happened again and again since the Gangetic delta was inhabited by man.
>
> If human experience and forethought could not always guard against such calamities, still less can the inferior animals avoid them, and the monuments of such disastrous inundations must be looked for in great abundance in the strata of all ages, if the surface of our planet has always been governed by the same laws. When we reflect on the general order and tranquility that reign in the rich and populous delta of Bengal, notwithstanding the havoc occasionally committed by the depredation of the ocean, we perceive how unnecessary it is to attribute the imbedding of successive races of animals in older strata to extraordinary energy in the causes of decay and reproduction in the infancy of our planet, or to *those general catastrophes and sudden revolutions so often resorted to.* Chap. xix. (p.p. 470—472).

That Lyell had the story of the Noachian deluge, and other "diluvial" theories in contemplation when he wrote these words cannot be doubted. The picture he gives of successive races of animals being overwhelmed and destroyed by disastrous inundations, and their remains being embedded in these deposits, is a representation of the effects of floods, which would appear to be amply sufficient to satisfy the diluvialist to whatever school he belonged, if it did not occur to the glacialist that the explanation of the drift and its contents applied equally to the same deposits after they had acquired the name of "glacial."

As to the age of existing deltas, he says:—

> "If we could take for granted that the relative level of land and sea had remained stationary, even since all the existing deltas began to be formed; could we assume that their growth commenced at one and the same instant, when the present continents acquired their actual shape, we might understand the language of geologists who speak of the epoch of existing continents. But the more we study the history of deltas from that imaginary fixed period, we become convinced that upward and downward movements of the land and contiguous bed of the sea, have exerted and continue to exert, an influence on the physical geography of many hydrographical basins, on a scale comparable in magnitude and importance with the amount of fluviatile deposition effected in an equal lapse of time."

We are now in a position to see a complete explanation of the drift deposits which were once called "Diluvial" now "Glacial."

It must be borne in mind that in the passages quoted from Lyell, he was treating directly of the effects produced by existing rivers, but in the passage referring to the inundations in Bengal, he connects these historic catastrophes with the inundations which "must be looked for in great abundance in the strata of all ages if the surface of our planet has always been governed by the same laws." Although he does not expressly connect these old inundations with the story of the Flood, he evidently regarded these natural occurrences as the true explanation of "those general catastrophes and sudden revolutions" such as that represented in that ancient story. Nor does he expressly use Buckland's term "diluvium" to distinguish the older drift deposits, which he describes so fully in his account of the drift of the Mississippi under the name of "loess," from the more recent or "alluvial" deposits due to the overflow of the existing rivers. It was not relevant to the subject of these chapters to enter into a discussion as to the relation of the older drift to the more recent, still less to enter upon a discussion of the difference in the conditions of the surface when the older drift was produced.

Probably his views as to the glacial period were too unsettled to admit of his devoting a separate chapter to the older or "Diluvial Deposits," which he could not have undertaken withont entering into a discussion of a very controversial character.

The following passage from Mr. H. B. Woodward's work previously cited will probably explain his avoidance of the term "diluvium":—

> "The word 'diluvium' was originally applied to deposits supposed to be formed or deposited during violent water action, such as would take place in periods of excessive rainfall, causing torrents of water in the rivers, floods, or deluges, or by the sea or rivers bursting through some bank or sea wall. It is a term now little used, owing to the deposits termed Diluvial being frequently misunderstood to indicate a Universal deluge. The term 'drift' is generally synonymous, and would naturally refer to beds formed from rocks at a distance from the localities where they have been deposited." "Geology of England and Wales," 1876, (p. 297).

In treating of these older drift deposits, in connection with the work done by existing rivers, Lyell recognises the fact that they were the products of older rivers, but he seems to have contemplated these older rivers as being rivers of the same character as the present, but flowing in different courses. He seems to have overlooked, or not given any express recognition to, the obvious inference from the facts which he had brought forward, that these older deposits were not the "alluvium" of large rivers flowing in well-established channels, but the products of water action, before any complete and permanent drainage system was established.

It is clear that rivers, which are incessantly carrying away the detritus of the land to form deltas in the sea, cannot have been the means by which large and deep masses of drift were spread and accumulated over the interiors of countries which these rivers now drain; however liable they may be to occasional floods leaving shallow deposits on the surface of their existing valleys.

Large rivers are developed by the confluence of smaller rivers and streams. Nature does not develop her drainage systems in the same way as man drains a town. Man makes his main drains first, and then connects the house drains with them. Nature makes her small drains first, in the shape of mountain streams and torrents, and shallow and shifting rivers, terminating in inland lakes, which would constitute the drainage system of a country for perhaps many thousands of years, before the inland waters had found any general and permanent outlet to the sea by established river courses.

The rainfall on any inland area may be assumed to have been the same, speaking generally, as it is now. A great part, if not the whole, of this rainfall which is now carried away rapidly to form the large deltas spoken of by Lyell, would be retained on the surface in lakes and bogs and changing water-courses; while the whole of the materials, produced by the denudation of mountains and the higher grounds, would be spread over the lowlands, filling up hollows, and here and there accumulating in masses, which would act as dams keeping back the water during periods of small rainfall, but which would be broken up and drifted about in times of heavy rain and floods. These deposits would be the "diluvial drift" of the older geologists spread more or less over every terrestrial area during the early periods of its existence above the sea.

If further we bear in mind that for a long time after the elevation of the land above sea level, the earth movements would probably have continued in activity, while the mountain ranges would be rising higher and higher and shedding more and more detritus as they rose, and while the lowlands would still be liable to disturbances of level, we need not call in aid a deluge or an ice sheet to explain the origin and spread of the drift, with its characteristic beds of boulder-clay, whether in Scotland, South America, or elsewhere.

The distinction between the older and more recent drift deposits would be strongly shown when a drainage system had been disturbed by some great earth movement, but in the absence of such disturbances it would seem probable that the contour of the levels and surface features, which govern the development of a drainage area or basin, as it is called, would be the same before and after a main drain had become established. In such cases there might be no well-defined line of demarcation between the older or "diluvial," and the newer or "alluvial," deposits, unless there were something in the character of the older deposits which would show that they were produced under a different condition of the drainage system of the basin through which a river now flows. This distinction is pointed out by Lyell in several cases, and furnishes complete evidence of the older deposits in a valley, such for instance as that of the Mississippi, having been produced by a very different drainage system to that now existing.

But such views could not have been entertained by the older geologists. In the search for the cause of the "drift," the scientific imaginations of geologists in the early part of the last century were fettered by the doctrines, not only that the contour of the earth's surface was the same at the time of the deposit of the Drift as it is now, but also that the time during which the Drift was being spread was far too short to admit of its being the effect of the normal operation of the denuding forces as now exhibited. But however long the lapse of time during or since the deposition of the drift in this or any other country, and in whatever way earth movements may have contributed to its production, it would be quite at variance with the theory attributing such movements to the secular process of the earth's contraction, to suppose that any large area, whether connected now with the same continental surface or not, or representing a straggling insular group like the British Isles, was elevated or depressed at the same time.

Each country, and the several areas now joined to form one large continental area, would have had its own period of elevation, its own "drift" or "diluvial" period, and its own "recent" period, when the present drainage system had become established after its last elevation above the sea. Athough the movements incident to a particular crust disturbance might be extended over a large portion of the earth's surface, long periods might elapse between the times when one part and another were affected; or the same area might be subjected to successive movements of elevation and depression incident to the same process of disturbance and settlement.

To what extent the older or diluvial drift deposits are to be found in different countries is a question of geography or stratigraphy. The fact that they are so common in almost every continent and island as to have given so much support to the story of the Deluge, and other diluvial theories, if not to that of the "Great Ice Age," is sufficient for our purpose.

There would, however, appear to be no ground for synchronising the period of the deposition of the Drift in different countries with any Palæontological or Biological period, as Sir A. Geikie seems to imply in representing the term "glacial" as an equivalent for "Postpliocene or Pleistocene."* Without further knowledge of the author's intentions in representing the Glacial period as commensurate with the Pleistocene life period, we cannot attempt to discuss this conception. The fauna and flora of the "Pleistocene" period were not confined to glacial or northern forms in other countries, whatever they might have been in Scotland and England, and we shall see below that the animals living in this country during the Pleistocene period were by no means confined to northern forms.

---

* See p. 3.

CHAPTER III.

CONNECTION BETWEEN THE DILUVIAL DRIFT AND GLACIERS. — CONDITIONS REQUIRED TO BRING BACK GLACIERS TO MOUNTAINS IN BRITAIN.

AS to the connection between the old drift and the old glaciers, we know that many existing continental rivers have their origin in glaciers, in some mountain range in the interior, however small the part played by these glaciers in contributing either water or detritus to them, in proportion to that contributed by the multitude of mountain torrents and other streams which drain the highland and lowland areas through which they flow towards the sea.

That, generally speaking, the large and numerous glaciers of former times were due simply to the greater height and mass of the mountains in which their vestiges are found, would seem to be little open to question.

As regards the mountains in England and Scotland, we have already referred to the old glacier of the valley of Llanberis. The denuding forces, incessantly at work for many thousands of years, while they have lowered greatly the heights of the Snowdon range, have at the same time carried away a great depth of surface soil from the slopes, and appear to have left only a few vestiges of old glaciers in parts above this valley.

As to the changes in the conditions required to bring back the old glaciers to the mountains of Britain, we have seen that in the opinion of Mr. Jukes-Browne a change in the ocean currents flowing past its shores, involving a current from the Arctic regions, instead of a current from the tropics would be almost sufficient in itself, and it is probable that, without any earth depression, subaerial denudation alone would have lowered the height of all our mountains which were in existence in early Pleistocene times by several hundred feet.

That, for instance, Ben Nevis is much reduced by denudation from what it was in height and mass in Pleistocene times, may be inferred from the following graphic account given by Sir A. Geikie in his "Scenery of Scotland," of the diminution which this mountain is now undergoing under the action of nature's denuding forces.

> "A more impressive lesson of the waste of a mountain side, and the lowering of a mountain top (than that given by Ben Nevis) could hardly be found. The narrow ridge is a mass of ruin, like the shattered foundations of an ancient rampart, and its fragments have been thickly strewn on the steep declivities below. The large pieces, as a whole, lie nearest the crest, though many a large block has toppled down into the depths of the glens.
>
> When detached from the solid granite, they still remain a prey to the wear and tear. Rain, frosts and snows, split them even further, and then as they slowly tumble over each other in their downward course, they become by degrees smaller, though still retaining their dry, angular surface. At last broken up many times in succession, they find their way down into the streams that thread the bottom of the glen. There, chafed against each other and the rocky channel, they are rolled into shingle and gravel. At last in the form of fine silvery sand, the waste of the far granite peak is either spread out in the quiet reaches of the stream as it winds through the valley, or hurried thence by the floods and swept out into the Atlantic waters of Loch Eil. The various agencies of erosion thus work steadily in concert. Those that wear down the flanks of the mountain cast no more debris into the streams than these can in the end sweep away. Hence each glen is insensibly widened and deepened, and each mountain as it decreases in circumference and in height, silently proclaims 'The memorial majesty of Time impersonated in its calm Decay.' "Scenery of Scotland" (p. 164).

As an illustration of the denudation by glaciers, Sir A. Geikie writes :—*

> "It has been estimated for example that the Justedal glacier in Norway removes from its bed 2,427,000 cubic feet of sediment annually. At that rate the amount removed in a century would be enough to fill up a valley or a ravine 10 miles long, 100 feet broad, and 40 feet deep."

NOTE.—This is only one of the numerous glaciers which descend from this mountain. (See below).

---

* Enc. Brit. "Geology."

In a chapter treating of Denudation in his "Geology for Students," Mr. Green quotes from a memoir by Sir A. Ramsay, and introduces a copy of a section showing that "an area of present surface in South Wales, not more than two square miles, was once covered with a great mass of Silurian and other rocks, which has been removed by denudation."

> "In every mile in length of an anticlinal, upwards of 2 cubic miles of material must have been swept off the present surface; enough to cover the whole of Great Britain to a depth of nearly a foot." (p. 407).

Elevation and denudation had probably removed the larger part of this mass before Pleistocene times.*

Assuming the mountains of Scotland and England to have the higher altitudes which they must have had in former times, there are facts which tend to show that no great changes in other conditions would be required to bring back glaciers to these parts. The British Isles are within the same degrees of latitude as Labrador and Kamtchatka. In the southern part of Norway the snow fields and glaciers of Justedal present a picture of arctic glaciation about 150 miles nearer the North Pole than the north coast of Scotland. The roof-shaped crest of Justedal rises from 4,600 feet to 5,400 feet high. Ben Nevis is 4,407 feet high. The snow line on Justedal is from 3,500 to 4,000 feet, or about 1,000 feet below the top of Ben Nevis, and its glaciers descend to about 426 feet above the sea. "Enc. Brit., Vol. xvii. (p. 578).

In a note to page 162 in his "Scenery of Scotland," Sir A. Geikie mentions that—

> "A well, fed from melted snow supplies the Ben Nevis observatory 64 feet under the top, but fails after a fortnight of dry summer weather."

But although the winter snow-cap on Ben Nevis does not now survive the summer heat, masses of snow are permanent in the hollows and fissures of this mountain and of the higher mountains of the Grampian Range.

---

* See also "Scenery of Scotland," chap. xvi.—Denudation of the Lowlands.

These facts furnish good grounds for supposing that no great change in the present conditions would be required to bring back a permanent snow cap and glaciers to Ben Nevis, and the other high mountains in Scotland and Wales.

In discussing the cause of the diminution of the glacier in Mount Kenya, Professor Geikie observed (as mentioned above) that—

> "A lowering of the temperature a few degrees, with increased precipitation, is probably all that would be required to bring back the old calotte to Mount Kenya."

We do not doubt that the principles on which this observation was based are correct, and that they apply to Ben Nevis as truly as to Mount Kenya.

PART IV.

SUPPOSED BIOLOGICAL EVIDENCE OF THE ICE AGE.

IF the Drift generally is the product of the causes and conditions referred to in Part III., we should expect to find in it remains of animal and vegetable life representing both forms belonging to anterior ages, which had been exhumed from their graves in the older rocks by the breaking up of the surface by earth movements, or the erosive action of water, as well as forms contemporary with the deposition of the Drift. The later forms, although they would only represent forms of life living in or visiting the country while the drift was being deposited and redeposited under the conditions referred to, might yet represent forms living at periods separated by long intervals of time.

In the drift deposited during Pleistocene times, bones of animals which lived in the Pliocene Age are found associated in the same beds with bones of animals which first made their appearance in these parts in the Pleistocene Age, and with bones of animals and remains of plants belonging to species living in this country in the present life period.

It was probably the discovery of the remains of animals, mingled with the remains of man himself, in the drift, that gave rise to the story of the Flood.

When the glacialists took over the "drift" from the Diluvialists, they had to take the bones with it. What these remains of animal and vegetable life found in the drift were, and how the glacialist has attempted to explain their presence in "Glacial Deposits," will appear from the following passages from the account given by Sir A. Geikie in continuation of the passage quoted in our first chapter :—

> "The Pleistocene deposits thus reveal to us a prolonged period of cold broken by shorter intervals of milder climate. The fossils which they contain throw curious and interesting light on these oscillations of temperature. Among the plants, leaves of arctic species of birch and willow are found far to the south of their present limits. On the other hand, remains of plants now confined to temperate latitudes are found fossil in Siberia, and others now living in more genial climates than those of Central Europe are associated in interglacial deposits with the remains of the still indigenous vegetation.
>
> To the same effect, but still more striking, is the testimony of the Pleistocene fauna with its strange mingling of Northern and Southern forms. The marine shells embedded in the glacial clays of Scotland, though chiefly belonging to species that still live in the adjoining seas, include a few that are now restricted to more Northern latitudes.
>
> Turning to terrestrial animals, we find among the Pleistocene deposits the remains of the last huge pachyderms, which through Tertiary time had been so striking a feature of the animal population of Europe. The hairy mammoth and the woolly rhinoceros now roamed all over the continent, and across Britain, which had not yet become an island. During the retreat of the snow and ice, they found their way into the forests and pastures of Northern Siberia. Driven southward when the cold increased, they were accompanied by numerous arctic animals which have not yet become extinct. Herds of reindeer sought the pastures of Central France and Switzerland; the glutton came to the south of England and to Auvergne; the musk sheep, and arctic fox wandered southward to the Pyrenees. But as each oscillation of climate slowly brought in a milder temperature and pushed the snow and ice northwards, animals of southern types made their way into Southern and Central Europe. Among these immigrants were the porcupine, leopard, African lynx. hyaena, elephant, and hippopotamus, the bones of which have been found in Pleistocene deposits."

The reader will see in this account the important part which the interglacial epochs of warm climate have to play in the story of the Ice Age. It might be thought that the term "Ice Age" or "Glacial Period" is only a picturesque expression for a period of great cold. But unless the "Glacial Period" produced the great Northern Ice Sheets it would have had no position in either Science or Fiction.

A "Glacial Period" or "a Great Ice Age" without ice would be a misleading misnomer. When Darwin saw in Mr. Croll's theory an explanation of the presence of Arctic plants in the

Alps and Pyrenees, it was not merely an increase of cold in the arctic regions that would have driven the arctic flora southwards, but an extension of the snow and ice of the polar regions far down into Europe, if not to the very foot of the mountains of Switzerland and Spain.* But if the "glacial" deposits themselves, or the deposits of the "glacial" period, in Scotland and England, show the existence of life in these parts during the "glacial" period, the introduction into the story of the "interglacial" epochs could not be avoided.

The extravagances of the glacial theory are its essentials.

Assume the truth of the story of the Ice Age as told by Sir A. Geikie in the passage quoted in the First Part, and the "interglacial periods" are absolutely necessary to prevent its fallacy being exposed at once by the evidence of life going on during its existence.

The glacialist's theory as to the geological evidence of these interglacial periods is thus explained by Sir A. Geikie:—

> "But the boulder clay, earths and gravels, left by the great ice sheet are not one continuous deposit. On the contrary they contain intercalations of stratified sand, clay, and even peat.
>
> In these included strata organic remains occur, for the most part those of terrestrial plants and animals, showing that the ice again and again retreated, leaving the country to be covered by vegetation, and to be tenanted by land animals, but that after longer or shorter periods of diminution it once more advanced southward over its former areas. *These intervals of retreat are known as 'Interglacial Periods.' Probably they were of prolonged duration, the climate becoming comparatively mild and equable while they lasted. The occurrence of the boulder-clay above the interglacial deposits shows a subsequent lowering of the temperature, with a consequent renewal of glacial conditious.*" "Class Book of Geology" (p. 355).

It is probably true that the remains of plant life are found more in stratified beds in the drift than elsewhere, but it is well known that the bones of animals have often been found in the boulder-clay itself. Sir A. Geikie himself gives an account of bones of elephant, Irish elk and reindeer, found in boulder-clay in Scotland,† as well as the sea shells in the boulder-clay of

---

* "Origin of Species" Popular Edition (p. 314—319).

† 'Transactions of Geological Society of Glasgow' quoted in "Glacial Nightmare" (p. 313).

Caithness. A bed of peat would undoubtedly be good evidence of the absence of an ice sheet over the place when the plants forming it were growing, but the appearance of such a deposit intercalated between beds of clay, would seem to bear a strong analogy to the succession of beds so common in coal measures.

If the relics of contemporaneous life during the glacial period were only found in the beds of "stratified sand, clay, and peat," intercalated between beds of "boulder-clay," as represented in this passage, the fact would give some support to the theory of interglacial deposits; but that there is little foundation for such a belief is shown by the following passage from Sir A. Geikie's "Scenery of Scotland" (p. 366).

> "The *boulder-clay* furnishes us with some scanty indications of the denizens of the country during the long period which it represents. Bones of the mammoth, reindeer, and of probably several species of oxen and deer, have been from time to time dug up, and doubtless the relics of other animals will yet be discovered in the older glacial deposits of Scotland; for scanty though the fauna might be, it need not perhaps have been less than that of modern Greenland."

This passage would seem to express another theory altogether as to the animals whose remains are found in the "glacial" boulder-clay. These animals are here represented as living, not only in the interglacial epochs, but throughout the entire glacial period. There is, undoubtedly, a scanty fauna in Greenland, which however does not include the elephant, or "many species of oxen and deer." The few species of animals existing in that country are able to do so because it is not entirely covered with an ice sheet. We shall not attempt to reconcile this passage, either with that quoted above referring to the interglacial deposits, or with the account of the great Northern Ice Sheet quoted in the first part of this treatise.

That the remains of life of any kind found in supposed glacial deposits could furnish corroborative evidence of the story of the Ice Age is preposterous. How could such remains furnish evidence of the prevalence of a climate so cold as to have produced ice sheets, which must have destroyed life of every kind and prevented its coming into existence during their continuance.

The supposed evidence of a cold climate furnished by the relics of animals and plants now belonging to more northern latitudes is valueless, when we find that those relics were associated with a large number of forms which are now living in the same parts, as well as with the remains of animals of a southern type, such as now are only found in tropical and sub-tropical regions.

Whether or not there is any difficulty in explaining the presence in these parts of various animals which now have their habitats in other latitudes, without assuming changes in the general climate, it is clear that the presence of a few northern forms cannot furnish any better evidence of the prevalence in these parts of a cold climate than the presence of the hippopotamus and the elephant imply the prevalence of a tropical climate.

But these problems are foreign altogether to the discussion of the Story of the Ice Age, as told by Sir A. Geikie. We need not trouble ourselves with the problem as to how these southern animals and plants were living in these parts at times when, according to his own account of the story, no ice sheets were in existence, and the climate was "comparatively mild and equable."

According to the above account of the interglacial periods, the time when these southern animals were supposed to be living in, or visiting, these parts, was when the climate was much the same as it is now. Sir A. Geikie represents the tropical animals as immigrants during the later part of the Ice Age. If such animals as the porcupine and the hippopotamus could live in these parts when the climate had not quite risen to its present temperature, there cannot be much doubt that the resources of science can furnish an explanation of the presence of the Arctic fox and the reindeer, and the Arctic willow and birch, in these or other parts of the temperate zone without requiring the occurrence of any kind of glacial period to account for it. The reindeer, according to Dr. Murray,* was hunted in Scotland in the 12th Century. The edelweiss and other Alpine plants now thrive well in gardens in Suffolk. Dr. Murray also tells us that—

> "The Indian tiger not only follows the antelope and deer in the Himalayan chain to the verge of perpetual snow; but the tiger, leopard, panther, and cheetah hunt their prey beyond that mountain range even in Siberia." id loc.

Changes in continental areas would appear to furnish a sufficient explanation of the presence of strange animals in Britain and in the European continent without any general changes of climate; while man himself has probably played the principal part in their extinction, from the time when he waged war against the Pleistocene races with flint axes and arrow heads, to the present time when he continues to carry on the work of destruction with the rifle.

* "Enc. Brit.," Vol. II. (p. 336).

PART V.

THE BOULDER-CLAYS OF EAST ANGLIA, AND THE CROMER CLIFFS.

IN Part I., Chapter ii. (page 6), we called the reader's attention to the remarkable limitation put by Sir A. Geikie to the extension of the ice sheet in England. According to his account, the ice sheet which covered the greater part of England and filled the Irish Channel and the North Sea stopped short at the Thames, and while covering the Eastern Counties did not extend into Kent or Surrey.

The surface soil of a great part of Norfolk, Suffolk, and Essex, is a stiff clay deposit known as the Chalky Boulder-Clay. Buckland gives a full description of this drift deposit in the passage cited above. Part II., chap. iii. (p. 38).

The discovery of a similarity between this boulder-clay and the "till" of Scotland, played an important part in the evolution of the ice sheet theory; as the great distance of the Eastern Counties from any mountain range on which glaciers could be supposed to have existed, precluded the supposition that this deposit could be the product of local glaciers.

While rejecting the notion that ice has ever had anything to do with the production of the chalky boulder-clay, we submit the following short account as furnishing a general explanation of the actual origin of this and the other drift deposits of East Anglia:—

The fundamental rock of East Anglia is the great chalk formation which now attains considerable heights in the Chiltern

Hills. The chalk formation slopes with a more or less disturbed inclination to the Eastern coast, where it disappears beneath the North Sea, to rise again above sea level in Denmark. That this great deposit has undergone many disturbances, involving undulations of its surface, as well as much contortion and dislocation in parts, is abundantly shown, not only by the fact of its surface being found at very different levels in East Anglia (appearing in some places as at Norwich 40 feet above sea level, and at Lowestoft and Yarmouth at about 500 feet below), but by the marvellous exhibition of upheavals, overturns, and contortions, exhibited in the coast sections of the south of England.

There can be no doubt that these effects were produced by a repetition of earth movements occurring during the long lapse of ages which have intervened between the first elevation of the chalk from its deep sea bed and the present day.

The Chiltern Hills would appear to represent a line of weakness corresponding somewhat to those of the Great Rift Valley in Africa, and the Andes Range in South America, and it is probable that this line of surface had been subjected to movements of upheaval and subsidence before the movement of elevation, which appears to have occurred in recent geological times.

The evidence of this last movement is the chalky boulder-clay itself, which is little else than detritus of the chalk hills in the west, together with a remaniè of London clay (deposited upon the chalk long ago, when it was as yet beneath the sea, in Eocene times), or a remaniè of still older deposits (the clays of the Upper Oolites, and the Kimmeridge Clay), which were brought up from beneath the chalk in a part where the processes of elevation and denudation were carried to such an extent as to remove entirely the chalk mass with which these old clays were covered.

This effect is shown by the disappearance of the chalk from the Fen District, and the spread of its debris, together with a large part of the Kimmeridge clay and the underlying Oxford clay, over the area of Suffolk and Norfolk.

The connection between this uppermost drift deposit and the chalk range (magnis componere parva) would appear to be the same as that of the drift of the plateau of South America and the Andes. It shows the same spread of mountain detritus over the lowlands to the east, in the form of a more or less continuous boulder-clay deposit, which covers the underlying strata (whether the solid chalk itself or later deposits), in wide patches continuous over considerable areas, or in small patches confined to a few square yards, varying also in depth from a few feet to some 40 feet and upwards where it has filled holes in the underlying strata.

In determining the origin of the chalky boulder-clay of the Eastern Counties, we have an advantage over the explorers of the Amazonian valley. The field of enquiry is limited to a distance of from 50 to 70 miles, along which the clays of which the drift of the northern part of the district is composed, can be traced from brickyard to brickyard, from the cliffs on the east coast to the pits in Cambridgeshire, where they are still lying undisturbed in their original bed of deposition.

The presence of Kimmeridge clay in the chalky boulder-clay of the cliffs and brickyards is shown by the numerous lumps of broken shale, in which the original laminæ, with the remains of small ammonites and other shells pressed between them, are preserved in an unaltered condition. That these are fragments of the bituminous shells of the Kimmeridge formation ("Kimmeridge coal"), is very clearly proved by putting them into fire, when they blaze brightly, and emit a strong bituminous smell.

As to the mode in which the detritus was produced, we have had a sufficient explanation in Sir A. Geikie's account of crust upheaval,* as illustrated by Darwin's account of the drift deposits on the slopes of the Cordillera.† The chalk was brought up by the same upheaving force as that which raised the Andes, when in their infancy they were only a low range of rising hills which the forces of subaerial denudation were destroying and removing as they rose. The altitude since acquired has been simply the effect of the long continuance or repetition of the elevating movements, which have overpowered the forces of denudation.

---

* Part III., chap. i.

† Part III., chap. ii.

That the elevating movement in the East Anglian area was continued after the deposition and distribution of some of the drift is shown by the appearance of beds of chalky boulder-clay on the tops and sides of some of the chalk hills themselves, and on the sloping sides of valleys; and by the fact that this clay forms the greater part of the surface soil of the highest lands in Suffolk and Norfolk, which must have been raised to their present height after the clay was spread over them.

But although the chalky boulder-clay is the latest of the drift deposits of East Anglia, it is not the only one. It is generally found lying on beds of sand and gravel, which have even a wider extension in East Anglia and its adjoining counties, than the chalky boulder-clay; and it is not uncommonly found lying on another and older deposit of clay which had a different origin altogether from that produced by the last elevation of the chalk range.

The history of the older beds deposited above the chalk and below the chalky boulder-clay, is to be gathered from the cliff sections of the East Coast. Most valuable information as to the stratigraphy of the cliff sections, and of the interior of East Anglia, has been furnished by the memoirs of Messrs. Searles Wood and F. Harmer, and the Geological Surveyors of the District.

The part of the coast in which the drift deposits, with which we are now concerned, appear in the cliffs is that extending from Southwold in Suffolk, to Weybourne in Norfolk. In the lower part of these cliffs, for nearly their whole extent, two series of beds are exhibited, representing deposits of periods separated from each other by a long lapse of time, as well as by earth movements, involving the substitution of a new for an old land surface. The lower or older beds belong to the Crag series and the Pliocene Age. The upper or drift series belong to the Pleistocene Age.

The Crag series is represented mainly by the beds of clay and sand known as the "Chillesford" beds, which undulate along the whole extent of the coast a little above and below the present sea level. These deposits appear to represent the bed of the estuary of a continental river and the ground of an old land surface which was inhabited by plants and animals during the following or Pleistocene period.

The "Chillesford" beds are covered with a confused and varying series of drift deposits, including what are known as the "Forest Bed" deposits, comprising the remains of plants and animals which inhabited the Pleistocene land surface, mingled with the remains of the previous, or Pliocene, life period. These drift deposits of land material are intercalated with, and covered by, a deep and continuous deposit of marine sand and shingle, which forms the main part and characteristic feature of the cliff section throughout this part of the coast, and which is continued inland over the whole of East Anglia and into the adjoining counties. It consists of marine or estuarine material deposited over this area during, what Mr. S. Wood called "The Great Submergence."

This area, at the time of the sinking movement, was probably an inland part of a large continental area, which extended far beyond the present coast line to the north and east. The depression does not appear to have submerged any part much below 300 feet, while the sinking surface was covered up pari passu with land and sea material washed over it as it sank.

This sinking movement was followed by a movement of re-elevation, which, while slowly raising the East Anglian area above the reach of the marine or estuarine waters, was operating with greater intensity in the line of the chalk hills in the west;—the effect of a continuance of these elevatory movements being, as previously noticed, the destruction of a large part of the chalk hills, and the spread of the detritus over the recent marine deposits which covered the lower land to the east.

These several drift deposits, including the marine sands and gravels, have been classified under glacial nomenclature as the "Lower, Middle, and Upper Glacial." In the high cliffs near Cromer the lower drift deposits occupy the whole section. Large masses of land drift are pressed and jumbled upon each other without any continuous line of superposition. The materials, however, can be clearly identified with the clays and sands in pits in the interior, and evidently represent masses of the old land surface drifted seawards during the slow sinking of the land, and deposited one upon the other as the land sank, while marine sands were washed into and among them by the incoming sea waters.

Lyell himself appears to have been originally responsible for the suggestion that these jumbled masses of boulder-clay in the Cromer cliffs were products of ice action. The numerous erratics occurring on the surface, and in the drift deposits of North-East Norfolk, had been explained as having been dropped by ice-bergs floating from the north, and melting in these parts when the land was under the sea, long before the glacial theory was thought of.*

We have seen above in the passage from Dr. Buckland's address in 1841, that it was part of the diluvialist's theory that floating ice was the agent by which large fragments of rock were carried to great distances from the mother bed.

In a paper written in 1840 "On the Boulder Formation in Norfolk," Lyell argued that if ice-bergs could carry large fragments of rock, they could also carry lighter material, and he suggested that these masses of boulder-clay were morainic materials dropped upon each other from icebergs as they melted. But if such a cause might explain heaps of such materials in a small area, it could not explain the deposition of the chalky boulder-clay over the whole of East Anglia. The insufficiency of the Iceberg theory was manifest. If, as Lyell had suggested, these boulder-clays were of glacial origin, a moving sheet of land ice could alone explain their spread over an extensive inland area.

---

* See "Glacial Nightmare," chap. i.

Some persons have seen evidence of the ice origin of the chalky boulder-clay in the scratches on the lumps of chalk and clay stone (septaria, &c.) and white flint nodules, which it contains in great abundance. A little close examination and consideration, however, soon satisfies the observer that these scratches, whether on the white silicious coating of the flint or on other substances, have all been made on a soft surface, and are nothing more than the natural effects of lumps of chalk or other material having a soft surface, and sharp angular fragments of flint, being rolled and pressed together in the process of drifting.

That these drifts are remarkable illustrations of boulder-clay could not be disputed, and if boulder-clay, wherever found, was the product of an ice sheet, the chalky boulder-clay of East Anglia would furnish ample evidence of the passage of an ice sheet over that area. It is apparently this view as to the origin of these drift deposits which led Sir A. Geikie to represent the great Northern Ice Sheet as covering the Eastern Counties, while it did not extend south of the Thames.*

That the boulder-clays of East Anglia were the product of ice seems to have been an important article in the glacialist's creed from early days, and to have been generally assumed as an established scientific doctrine by the geological surveyors and other stratigraphists engaged in the investigation of the geology of this district. If the results of their investigations have not furnished conclusive evidence against the supposition that Ice sheets have ever been present in East Anglia, their memoirs have contributed nothing substantial in support of any glacialistic explanation of these drift deposits except by their authors' having adopted the glacialist's system of classification and nomenclature to denote the position of the beds they treat of.

---

* See Part I., chap. i. (page 5).

To pass from attempts to explain these deposits by false and fictitious causes, to an explanation more in accordance with the general principles of geology, we will call the readers attention to a passage from Lyell which will throw much light upon the facts exhibited in these cliff sections.

In Chapter XIX of his "Principles of Geology," Lyell gives an account of the section disclosed by a boring for an artesian well at Fort William near Calcutta, which shows a superposition of beds during a slow process of sinking, to which that region was subjected, somewhat similar to that exhibited in the cliffs of the Suffolk and Norfolk coast. He tells us—

> "The boring was carried to a depth of 481 feet below the level of Calcutta, and the geological section obtained in the operation has been recorded with great care. Under the surface soil, at a depth of about 10 feet, they came to a stiff blue clay about 40 feet in thickness, below which was sandy clay containing in its lower portion abundance of decayed vegetable matter, which at the bottom assumed the character of a stratum of black peat two feet thick. The peat mass was considered as a clear indication (like the dirt bed of Portland), of an ancient terrestrial surface. It appears, therefore, that there has been a sinking down of what was originally land in this region to the amount of about 70 feet or more, for Calcutta is only a few feet above the level of the sea, and the successive peat beds seem to imply that the subsidence of the ground was gradual and interrupted by various pauses......
>
> Continuing the boring at Fort William, they entered below the vegetable mass upon a stratum of yellowish clay about 10 feet thick.........After penetrating 120 feet they found loam containing water-worn fragments of mica slate and other kinds of rocks, of a size which the current of the Ganges can no longer transport to this region. At a depth of 380 feet, clay with the fragments of lacustrine shells was incumbent on what appeared clearly to have been another dirt bed or stratum of decayed wood, implying a period of repose of some duration and a forest covered land, which must have subsided 300 feet to admit of the subsequent superposition of the overlying deposits.

> It has been considered that at the time when this area supported trees, the land extended much further out into the Bay of Bengal than now, and that at later times the Ganges, while enlarging its delta, has only been recovering lost ground from the sea."
>
> "Principles," Vol. I. (p. 476).

We would say in conclusion that it has not been our object to explain in detail the history of the drift deposits, in this or any other country (this would require a stratigraphical knowledge which we do not claim to possess), but to show that the general principles of Geological science would seem to furnish a sufficient explanation of the mode and circumstances under which these deposits were produced, without calling in aid such anomalous and paradoxical events, as either a Universal Deluge or an Ice Age.

SUPPLEMENT

TO

"THE FICTION OF THE ICE AGE."

CHAPTER I.

IN treating of the story of the Ice Age in the preceding pages, we introduced Sir A. Geikie's account of the theory of the cooling earth, and its consequent contraction, as the cause of the elevation of mountains and of other crust movements, but we made no reference to the connection between the theory of a cooling earth and that of changes in climate.

A little consideration will show that however separated the two theories may be in scientific literature and thought, the two classes of phenomena are connected in nature as accompanying effects of one and the same cause.

The belief in a cooling earth directly involves a belief that the earth was at one time hotter than at present ; and that it has been cooling through the secular process of radiation of heat through the crust into space, and it is a reasonable, if not necessary inference, that whether or not, the internal heat of the earth has now any appreciable effect on the temperature of the surface and the atmosphere lying upon it, it must have had such an effect in the earlier stages of the process of cooling, and *e converso* that the process of cooling must have been accompanied by a refrigeration of the climate of the earth, so far as its temperature depended upon the internal heat.

If we look back to the writings of the earlier physicists or geologists before Lyell, we shall find that many not only recognised in the internal heat of the earth the cause of volcanic action, but also in the diminution of this heat, the main cause of the change of the climate of the earth, from that of an equal temperature in the earlier periods to the varied temperatures of later periods.

The doctrine of internal heat being the source of volcanic energy as now exhibited, is mentioned in a note to the introduction of Conybeare and Philip's Geology (1822), p. xviii.

> "The very important recent discoveries with regard to the increased temperature noticed in descending deep mines by Messrs. Fourrier and Fox, will, if confirmed by further examination, prove that some great source of heat exists beneath the earth's crust.
>
> A degree of presumption may be thought to arise from these considerations that the crust of the earth rests on a heated nucleus, the true source of volcanic energy."

In Richardson's Geology, edited by Dr. Thomas Wright, and published in 1851, the existence of a heated interior is represented as a well ascertained fact,

> "The increased temperature of wells and mines, the warmth of which augments in a known ratio as we descend, the vaporous exhalations of the earth, its streams of heated water and its volcanic eruptions, all prove the existence of such a cause."

Almost immediately following this passage is a paragraph on the tropical heat of the ancient earth.

> "Among the varied contrasts afforded by the past and present conditions of our Globe, must be enumerated the fact, so clearly demonstrated by the organic remains entombed in the fossiliferous rocks, that the climate and character of the productions now limited to the immediate vicinity of the equator once extended to latitudes far removed from that line."
>
> "It is only, says M. Deshayes in the second era of the tertiary period—the Miocene—that the climate of the Earth cooled from a degree of heat equalling that of the equator, to a temperature equivalent to that of Gambia and Senegal, while it was only at the third or more recent epoch that it assumed a European character."

After noticing the hypothesis proposed by Sir G. Lyell, Mr. Babbage and Sir John Herschell, to account for this change of climate, the writer says :—

> "Whatever be the cause, the fact is indisputable. The tropical climate of the primeval earth is demonstrated by the character of its productions, and we are compelled to admit that a cause then prevailed, or possibly a combination of the causes above enumerated, which was sufficient to overcome the effect of the diurnal and annual motion of the globe, and to render its surface a vast hot-house, calculated for the growth of ultra-tropic forms of animal and vegetable life."

In this passage the writer, while representing the present internal heat of the globe as proved by the evidence of the gradual increase of temperature discovered in deep borings and mines, as well as by the volcanic energy still exhibited, introduces the evidence of organic remains found in fossiliferous rocks as demonstrating the extension of a tropical climate in earlier periods to latitudes far removed from the equatorial region, and while not expressly stating his own belief that the warmer climate of the earlier periods was due to the greater power of the internal heat, he evinces a strong inclination to adopt it by quoting the passage from M. Deshayes, in which this belief is very distinctly announced.

There can be little doubt, we think, that if this writer had been in possession of the facts which enabled Sir A. Geikie to propound with such confidence the theory of a cooling earth, he would not have hesitated to adopt M. Deshayes' views as his own.

We would observe here that geologists and biologists, whatever their theory of cause may have been, have recognised the fossil remains of animals and plants as evidence of the climate of the period in which they lived, whether they have been found in the more ancient, or more recent, deposits.

Lyell's views on the subject are well known. He did not call in question the pristine heat of the earth, but he held that the consolidation and cooling of the crust had advanced before the earliest period, in the deposits of which any remains of organic life have been found, to such a stage that the internal heat, if it continued to exist at all in the innermost part of the earth, had ceased to have any effect, either as a cause of volcanic action, or as a cause of the hotter climate of the earlier periods, for which he thought he saw a sufficient explanation in changes in distribution of land and sea on the earth's surface. He attributed the origin of volcanoes and other crust movements to heat generated by chemical action in the solid and cooled crust itself, and excluded from the domain of geological science the pristine heat of the earth as a cause not belonging to his repertory of causes now in action.

In Chapters X. to XIII. of his "Principles of Geology," 17th edition, we find this great authority directly controverting the older theory of the effects of the internal heat, and substituting for it a theory of the causes of changes of climate which would be consistent with the earth having cooled from surface to centre, before the earliest life bearing period known to science was brought into existence.

> "The gradual diminution of the supposed primitive heat of the globe has been resorted to by many geologists as the principal cause of alterations of climate. The matter of our planet is imagined, in accordance with the conjectures of Leibnitz, to have been originally in an intensely heated state, and to have been parting ever since with portions of its heat, and at the same time contracting its dimensions. There are, undoubtedly, good grounds for inferring, from recent observations and experiments, that the temperature of the earth increases as we descend from the surface to that slight depth to which man can penetrate; but there are no positive proofs of a secular decrease of internal heat accompanied by contraction."

Lyell fully accepted the records of underground temperatures, and the evidence they afforded of a gradual increase of heat in penetrating the crust, but instead of regarding these facts as evidence of a heated interior he argued that the rapidity of the rate at which the heat was found to increase proved that it could not be connected with a highly heated nucleus. He assumes that if it were so, and the heat increased at the same rate (of 1° Fahr. in 65 feet), to the earth's centre, the heat of the greater mass of the earth would be so intense that the external crust could not escape fusion. (Vol. II. p. 207.) He ignores altogether the effect of the process of cooling in diminishing the heat of the interior, as well as that of the outer crust, while his assumption that the rate of increasing heat, maintained generally in the upper crust, would be continued further into the interior, is not at all a necessary inference.*

---

*See the opinion of Lord Kelvin cited in Green's "Geology," p. 490, and Sir A. Geikie's Explanation of a Cooling Earth, Class Book of Geology, Chapter XVI.

In rejecting the internal heat of the earth as the cause of volcanic action and crust movements exhibited in the present as in the past, Lyell excluded from his system the most striking illustration the story of our planet affords of the truth of his own great principle, the uniform operation of the laws of nature; while in attributing the change in the climate of the globe, as evinced by the records of organic life, to vicissitudes of climate brought about by changes in land and sea, he introduced into his system a cause manifestly inadequate to meet the requirements of the problem, but which found its logical development in the astronomical theory of Mr. Croll, and "The Story of the Ice Age."

We submit that in excluding from his system the doctrine that the internal heat of the earth was the cause of the warm climate of the earlier periods, and that the diminution of that heat, resulting from the secular process of radiation, was the cause of the refrigeration of climate in ultra-tropical regions in later periods, he excluded the recognition of the main cause of this change of climate, as well as a very efficient cause in the evolution of those new forms of animal and vegetable life, whose appearance in later deposits has been regarded as evidence of that change.

In the theory of a still cooling earth, as expounded by Sir A. Geikie, we find a direct contradiction to Lyell's views, and a restoration to science of the doctrine of the earlier geologists, which the result of modern researches in underground temperature has now placed on a well assured footing.

In his Article in the "Encyclopædia Britannica" previously referred to, he makes the following statements with respect to the result of recent researches in underground temperatures.

> "In the evidence obtainable as to the *former history* of the earth, no fact is of more importance than the existence of a high temperature beneath the crust, which has now been placed beyond all doubt. This feature of the planet's organization is made clear by the following proofs" (he mentions (1) Volcanoes; (2) Hot springs; (3) Borings for wells and mines, &c.)
>
> "It is a remarkable fact now verified by observation all over the world that below the limit of the influence of ordinary seasonal

> changes, the temperature, so far as we know, is no where found to diminish downwards. It always rises, and its rate of increment never falls much below the average. The only exceptional cases occur under circumstances not difficult to explain...........
>
> But beneath the limit, to which the influence of changes of season extends, observations in most parts of the world show that the temperature invariably rises as we penetrate towards the interior of the earth. According to our present knowledge the average rate of increase amounts to 1° Fahr. in every 50 or 60 feet of descent, and this rise is found whether the boring is made at the sea level or on high ground."

In this passage Sir A. Geikie adduces the well ascertained fact of the present heat of the interior of the earth, as "evidence as to the *former history*" of the earth, although he does not expressly allude to the connection between this evidence and the theory of a cooling earth, which he had expounded in another part of the same article.

In his "Class Book of Geology" he tells us (p. 94),—

> "The cool, solid, outer shell is far too thick to be pierced through by human efforts, but by various kinds of observations more or less probable conclusions can be drawn with regard to this problem. In the first place it has been ascertained that all over the world, wherever borings are made for water or in mining operations, the temperature increases in proportion to the depth pierced, and that the average rate of increase amounts to about 1° Fahr. for every 64 feet. If the rise of temperature continues inward at that rate, or at any rate at all approaching it, then at a distance from the surface which in proportion to the bulk of the globe is comparatively trifling, the heat must be as great as that at which the ordinary materials of the crust would melt at the surface."

It is clear from this process of reasoning that to whatever depth the outer shell of the earth may be solid, it is still very hot within a few miles of the surface.

It is equally certain that whether or not the influence of the internal heat is now appreciable in the surface layer itself, the heat is still passing through it, whether it be the frozen ground of the Polar regions or the warm ground of the Equatorial regions.

In the Article in the "Encyclopædia," from which the previous extracts were taken, we are told that there is

> "A zone of invariable temperatures between 60 and 70 feet down, in temperate regions. At Yakutsk, in Eastern Siberia, the soil is permanently frozen to the depth of 700 feet. In Java, on the other hand, a constant temperature is said to be met with at only two or three feet."

The zone of invariable temperature would be the part nearest to the surface, where the temperature is found to be unaffected by a variation in the sun's heat coming from above.

If the distance from the surface of this zone is in temperate regions 60 or 70 feet, rising to some two or three feet in the equatorial zone, the crust of the earth can only be called "cool" relatively to the greater heat of the interior.

As to the ground in Yakutsk being frozen to the depth of 700 feet, this does not quite agree with the information we have received as to the depth of frozen ground in the Klondyke district in North America at about the same latitude. It appears to be the opinion of persons who have been engaged in mining operations in this district that the frozen ground does not extend for more than 200 or 250 feet, while it is a well-known fact that in the Cassiar district, some 100 miles south-east, the ground is not permanently frozen at all; the effect of the winter frost being so completely removed by the heat of the summer sun that no fires are required to melt the ground for mining operations. We learn from the same source of information that the greater depth reached by the frost in the Klondyke district is attributed to its small snowfall, and the absence of a thick covering of snow to check radiation, whereas in the Cassiar district the snowfall is much heavier, and the snow-cover on the surface much thicker.

The following passages from Ganot's "Physics," (edition of 1898, Atkinson's translation), show the present view of physicists on this subject, p. 483):—

> "Terrestrial heat.—Our globe possesses heat peculiar to it, which is called terrestrial heat. The heat from the sun penetrates slowly by conduction into the interior, and accordingly the maximum temperature will be at different depths at different times.......... From observations of this kind it is concluded that the solar heat does not penetrate below a certain internal layer, which is called the layer of constant annual temperature. The depth below the external surface varies of course at different parts of the globe; at Paris it is about 30 yards, and the temperature is constant at 11·8° C. Below the layer of constant temperature, the temperature is observed to increase on the average 1° C for

> every 80 feet. The most rapid increase is at Irkutsk, in Siberia, where it is 1° C for 20 feet, and the slowest in the mines of Mansfield, where it is about 1° C for every 330 feet. This increase has been verified both in mines and artesian wells. According to this, at a depth of 3000 yards the temperature of a corresponding layer would be 100° C." (the temperature of boiling water) " and at a depth of 20 or 30 miles there would be a temperature sufficient to melt all substances which exist on the surface. Hot springs and volcanoes confirm the existence of the central heat.
>
> Various hypotheses have been proposed to account for the existence of the central heat. The one usually admitted by physicists is that the earth was originally in a liquid state, in consequence of the high temperature, and that by radiation the earth has gradually solidified so as to form a solid crust. The cooling must be very slow owing to the small conductivity of the crust. For the same reason the central heat does not appear to raise the temperature of the surface more than one-thirty-sixth of a degree."

If the influence of the internal heat on the surface at the present time, however slight and unappreciable, represents a late stage in the process of cooling, which has been going on since our planet began its revolutions round the sun, it is a very reasonable and obvious inference that the upper crust was much hotter in earlier stages of the cooling process than it is now, and that there must have been a very long period when the internal heat was not only sufficiently powerful to make itself felt everywhere within a much shorter distance of the surface than now, but to warm the surface layer itself and the atmosphere upon it.

We have seen in the passage above cited from Lyell, that he was fully aware that many geologists at his time had regarded the diminution in the primitive heat of the earth as the principal cause of alterations of climate. While rejecting this theory, he, at the same time, as we have seen above, repudiated the doctrine that the heat of the earth had anything to do with volcanic action now exhibited.

Sir A. Geikie, while recognising in the present high temperature of the upper crust evidence as to the *former history* of the earth, and while restoring to geological science the theory of a cooling earth, as a cause still in action, makes no allusion to the effect of the cooling process on climate, or to the support given to the old theory by the character of the animal and vegetable forms discovered in the deposits of different periods, which all scientists concur in regarding as evidence of the climate of the time in which they lived.

We submit that in restoring the theory of a cooling earth he has restored the true explanation of the change of climate demonstrated by the life records of the earlier and later periods, and that neither Lyell's theory of vicissitudes of climate, nor Mr. Croll's astronomical theory of successive periods of warm and cold epochs, nor the theory of a Glacial epoch in the Pleistocene, or any previous period, have any place in a system in which the doctrine of a cooling earth occupies such an assured position as that given to it by Sir A. Geikie.

The true history of the climates of the world, the true story of "Climate and Time" tells of a gradual refrigeration of climate in extra-tropical regions, accompanying the diminution of internal heat. from the earliest period of our planet's existence to the time when the process of refrigeration had culminated in the development of permanent snow and ice in the Arctic and Antarctic regions—an event which has been misrepresented by Lyell and his followers as an instance of vicissitudes of Climate, and which still occupies an incongruous position in Sir A. Geikie's system as the "Story of the Ice Age."

The following passage from Mr. Croll's introduction to his work "Climate and Time" (1875), p. 6, shows very clearly his view of the geological opinion then prevalent, which induced him to elaborate his astronomical theory of the Glacial Hypothesis, and also shows the very important part which the "*great discovery of the Glacial Epoch*" played in the matter.

> "It has all along been an admitted opinion among geologists that the climatic condition of our globe has not during past ages been uniformly the same as at present. For a long time it was supposed that during the Cambrian, Silurian and other early geological periods, the climate of our globe was much hotter than now, and that ever since it has been gradually becoming

> cooler, and this high temperature of Paleozoic ages was generally referred to the influence of the earth's internal heat. Not only is the theory of internal heat *now generally abandoned, but it is admitted that we have no good geological evidence that climate was much hotter in Paleozoic ages than now, and much less that it has become uniformly colder.*
>
> *The great discovery of the Glacial epoch*, and more lately that of a mild and temperate condition of climate extending during the Miocene and other periods to North Greenland, have induced a complete revolution of ideas in reference to geological climate. ....To account for these extraordinary changes of climate has generally been regarded as the most difficult and perplexing problem that has ever fallen to the lot of the geologists."

After noticing certain astronomical theories he says :—

> "The only other theory on the subject worthy of notice is that of Sir Charles Lyell. These extraordinary changes of climate are, according to his theory, attributed to the difference in the distribution of land and water.......But supposing that difference in the distribution of land and water would produce the effects attributed to it, nevertheless it would not account for those extraordinary changes which have occurred during geological epochs. *Take for example " The Glacial epoch.*"

He then proceeds to construct his astronomical theory to explain the occurrence of a Glacial period in Pleistocene times in accordance with the conditions of a cooled crust as laid down by Lyell.

The following short review of the accounts given by Lyell and Sir A. Geikie of the evidence of climate in past ages will show how far this evidence bears out the theories of Lyell and Croll.

The reader will bear in mind that the question as to the effect of this evidence is not, whether it does or does not prove the prevalence of a warmer climate or climates in past ages than that of the present day, which is admitted on all sides, but whether it shows a progressive change from a warmer to a cooler climate, such as would be the natural and necessary effect of a cooling earth.

CHAPTER II.

LYELL'S ACCOUNT OF THE CLIMATE OF FORMER GEOLOGICAL PERIODS.

IN his Ninth Chapter, Lyell gives an account of the "Development of organic life in successive Geological Periods." Although he does not, in this chapter, express any recognition of a connection between changes in the condition of the earth's surface, and the appearance in the world of new and advanced forms of life, he follows the natural and actual sequence of Biological phenomena, commencing with the oldest fossiliferous periods, and tracing the introduction of new forms up to the last of the Tertiaries and the appearance of man.*

In treating, the subject of climate, however, he adopts a different course. He reverses the natural order, and gives a retrospective account of the climate of past ages, commencing with that of the present period. Such a course was manifestly suitable to a theory that the causes and conditions affecting climate, would be the same in the earliest as in the latest periods, and that the mysteries of the past were to be solved by our knowledge of Nature's operations as exhibited in the present.

He thus introduces his theory of "Vicissitudes in Climate."†

---

*See further as to this below, Chapter IV.

†"Principles of Geology," 12th Edition, Chapter X. (p. 172).

> "Another objection to the theory which endeavours to explain all geological changes by reference to causes now in action, is founded on the former prevalence of climates hotter than those now experienced in corresponding latitudes.
>
> Since I first attempted, in the year 1830, to account for vicissitudes of climate by reference to changes in the physical geography of the globe, our knowledge of the subject has greatly increased, and the problem to be solved has assumed a somewhat different aspect. *More extended observations have shown that in times past the climate of the extra-tropical regions has been by no means hotter than now, but on the contrary there has been at least one period, and one of modern date geologically speaking, when the temperature of those regions was much lower than the present.* It will be desirable, therefore, before entering into a discussion of the probable causes of changes of temperature which have been experienced since the earliest of the fossiliferous rocks were formed, to lay before the reader a brief account of the evidence by which the reality of such changes has been established."

This passage throws much light on the confusion of theories with respect to this subject exhibited in the later Editions of "The Principles," as well as on the connection between Lyell's later views and the introduction of the Glacial Theory.

It appears that the greater knowledge acquired between 1830 and 1875 was the discovery of the "Glacial Period" of Pleistocene times; in other words his acceptance of the Story of the Ice Age as told by Agassiz and Ramsay and Mr. James Croll.

As to the climate of the extra-tropical regions having been no hotter in the past, than now, we shall see shortly that his own accounts of the climates of former periods give no support to this statement on this crucial question.

He commences his retrospective survey with the climates of the "Age of the Mammoth," and "of the European drift and cave deposits," and then devotes several pages to the next period, which included the recently discovered "Glacial Epoch."

He adopts the new theory to a certain extent, and introduces the so-called "Glacial Epoch" into his own system as an instance of the intervention of a very cold climate between periods of warm climate, which furnishes, at all events, one illustration of his own theory of "vicissitudes in climate."

In passing on to the Pliocene Period he says (p. 197)—

> "When we pass beyond the ages when a colder temperature prevailed, and receding a step further into the past, examine the fossils of the British Pliocene Strata, we find in the earliest or lowest members of them *very interesting proofs of a climate warmer than that now prevailing in England, and more resembling that of the Mediterranean.*"

In introducing his account of the Miocene Age, he writes (p. 198):—

> "The next step on our retrospective survey carries us to the movements of the Upper Miocene Period..........
>
> The Upper Miocene flora and fauna of the whole of Central Europe afford *unmistakable evidence of a climate approaching that now only experienced in sub-tropical regions.* In the newest deposit of the Upper Miocene formation, Professor Heer has detected at Œninghen, in Switzerland, the leaves, fruit, and sometimes flowers of about 500 species of plants, in which we find a near resemblance to the flora of the Carolinas, and other Southern States of the American Union."

As to the revelation of a rich vegetation in the Arctics in the Miocene Period, which was considered so marvellous when first heard of, he says:—

> "The lower Miocene flora has been traced from Italy northwards to Devonshire and even to Iceland. The extent to which the Miocene flora flourished within the Arctic circle even as far towards the pole as our exploring expeditions have penetrated, has been clearly pointed out by Professor Heer in an important treatise on the fossil flora of the Arctic regions."*

While bringing before his readers the evidence of the warm climates of this and other periods, he does not omit to keep in position his own theory that these warmer climates of past ages represented vicissitudes of warm and cold climates, rather than a continuous change of a warmer to a colder climate.

He does this by introducing paragraphs referring to the evidence of ice action in each period, whether there was or was not any evidence actually discovered of such an occurrence. These notices appear very prominently in the headings and margins of the pages.

*As to these discoveries we refer the reader to the account given by Sir A. Geikie below, Chapter III.

Accordingly, after giving a full account of the evidence of warm climate in this period, he introduces a paragraph headed "Ice Action in the Miocene Period," (p. 203.)

> "If it be asked whether in the entire Miocene series there are no indications of intercalated spells of colder climate, like the Glacial episode before mentioned, as intervening between the older Pliocene period and the modern eras, I may reply that there are none which can at present be established on organic evidence. But our geological records are far too fragmentary to entitle us positively to assume that in the course of so vast a succession of ages there were no oscillations of temperature analogous to those which certainly occurred between the close of the newer Pliocene period and our own time."

So soon has he to fall upon the defects in the Geological record to explain the absence of evidence in support of his own theory.

In the manner in which he expresses himself in this passage, Lyell would appear to have forgotten that it was only his own doctrine of a cooled, instead of a cooling, earth which would have led anyone to believe in the probability of epochs of cold occurring in earlier periods of the world's history.

After noticing the absence of any evidence of a cold climate in this period furnished by organic matter, he cites (p. 204)—

> "An occurrence of erratic blocks in a marine deposit in Piedmont of such a size and in such a position as to make it impossible at present to account for these transportations by any other cause than the buoyant power of ice."

After discussing the *pros.* and *cons.* of this view, he suggests that—

> "Perhaps a lofty mountain with a glacier reaching to the sea would be the least objectionable hypothesis."

We are not aware of any reason why there should not have been a lofty mountain with glaciers on its summits in the neighbourhood of Piedmont in Pliocene times as there is now, but if there were it would not imply any colder climate than that of the present day.

In his account of the organic remains of the Eocene period, (p. 207), he mentions, among other evidences of a warmer climate, the remains of a flora in the Isle of Wight, which, according to Heer, resemble in many respects plants of the tropical regions of Australia and India, and in the lower Eocene strata of the London clay in the Isle of Sheppey "fossil fruits of the cocoa-nut, screw-pine, and custard-apple, reminding us of the hottest part of the globe."

As to "supposed signs of Ice-action in the Eocene period," (p. 207), he refers to the presence of blocks in a coarse conglomerate in the Alps known as Flysch, which "present phenomena analogous to those of the neighbourhood of Turin" mentioned above. After noticing the different opinions expressed as to the origin of these blocks, he says—

> "It would, perhaps, be most in accordance with existing analogies to suppose a mountainous island occupying the site of the Austrian and Swiss Alps from which glaciers descended to the sea."

This would seem to be not an unreasonable explanation, but it would be one which would not imply a colder climate any more than the glaciers now present in high mountains in the tropics imply the absence of a tropical climate in the plains below.

In introducing his account of the Cretacean Period in his next Chapter (Chapter XI. p. 211), he makes this important admission,—

> "An examination of the fossils of the Pliocene, Miocene, and Eocene strata, viewed successively in the order of their higher antiquity, afforded us evidence of *a temperature continually increasing in proportion as we recede further from the glacial Epoch*"

Of this progressive increase of temperature, his theory of vicissitudes of climate could furnish no explanation, but it obviously is directly in accordance with the theory of a cooling earth.

As to the evidence of climate furnished by the fossil remains of the Cretacean era, he writes in p. 213:—

> "The plants of the Upper Cretacean formation in Europe, so far as they are known, have such an affinity with the Eocene flora as to point in the same direction in regard to the existence of a high temperature. They contain a large number of dicotyledonous angiosperms whereas the lower cretaceous rocks are characterised by the absence of the last, and by a predominence of cycads and conifers of an araucarian type, and of ferns referred by some botanists to genera which favour the hypothesis of a warm climate."

In his account of the development of organic life in Chapter IX., he gave much more notice to the appearance of dicotyledonous angiosperms in the upper Cretacean formation. He referred to the discoveries at Aix la Chapelle, in which

> "We at length meet with an assemblage of fossil plants, in which the principal classes and orders of the living vegetable creation are fully represented."

We shall notice more fully the occurrence of an important change in the organization of plants in the fossil remains of the Cretacean Period when we come to Sir A. Geikie's account of the climate of that Period.*

As to the evidence of the occurrence of an epoch of cold climate in the Cretacean period, he heads two pages with the words "Floating Ice in the Sea of White Chalk" (215-216). But the only fact mentioned is the discovery in the white chalk of the South-west of England of isolated pebbles, or small fragments of rock, in one case a group of such stones, one weighing upwards of 24 pounds. He tells us that he had himself attributed the presence of these stones in chalk to their having been drifted from the land out to sea, entangled in the roots of trees—a fact mentioned by Mr. Darwin as of frequent occurrence in the Pacific. But he had since agreed with Mr. Godwin-Austen that some of these stones were too large to be carried out to sea without the agency of ice. He adds, however, that "large angular blocks have not been met with in the white chalk of such a size as to imply the agency of glaciers and ice-bergs."

As there is no reason to suppose that there were not rivers, with trees growing on their banks, and floods, in Cretacean times, the drifting seaward of trees with pebbles and stones entangled in their roots, must have been a frequent occurrence then as now, and one which would appear to furnish a very probable explanation of the problem, however convenient Mr. Godwin-Austen's suggestion might be to support Lyell's own theory of the probable occurrence of a cold epoch in Cretacean times.

*See below, Chap. III.

He then passes on to the climate of the Oolitic and Triassic periods, (p. 217). He cites Professor Heer's opinion that the evidence of climate in Switzerland during these periods implied a prevalence in that latitude of a climate like that of the West Indies.

As to the intercalation of a cold epoch during these periods, he only mentions in a short paragraph a suggestion of Mr. Godwin-Austen, that some fragments of rock found in the New Red Sandstone implied the transport of ice, which, however, he represents as having been controverted by Mr. Pengelly.

Of the climate of the Permian Period, he writes :—

> "The fossils of the Permian formation are very like those of the antecedent Carboniferous strata, and indicate the prevalence of a warm and moist climate throughout a great part of the Northern Hemisphere."

As to supposed signs of ice action in the Permian Period he cites (p. 222), a statement of Professor Ramsay, that some scattered pieces of rock, found in a brecciate conglomerate of this age in England, had led Ramsay to infer the action of floating ice in the seas of that remote period. He is fully satisfied that the specimens were taken out of the breccia, and says that the explanation offered by Professor Ramsay "seems to me the most natural, indeed the only one in which in the present state of science can be suggested." He at the same time cites the opinion of Professor Suess, "who has studied the Permian conglomerate or Rothliegende in various parts of the Alps, and who says that it shows no signs of ice-borne blocks having there been met with."

The presence of scratched pieces in a drifted deposit of rock fragments would seem to be too obviously appropriate to the character of the deposit to require ice action for its explanation.

He then notices at some length the climate of the Carboniferous Period, (p. 224). He cites the opinion of botanical authorities as to climate implied by the plants of the coal measures, and gives as his own conclusion that

> "They probably flourished in an atmosphere highly charged with aqueous vapour, and such an atmosphere must have been warm." (p. 225).

He notices the great extent of coal measures in northern regions, and the discovery of plants of the same character as those of the European Carboniferous formation, as high as Lat. 74° 36' N. He does not mention any suggestion of evidence implying a variation in the general climate of this period.

In his account of the climate of the Devonian period he observes that the plant remains are so similar to those of the Carboniferous period that they point to a similarity of climate.

As to the "supposed signs of ice action in the old Red Sandstone or Devonian Period," he mentions

> "That the Rev. J. G. Cuming, in 1848, in his 'History of the Isle of Man,' compared the conglomerate of the old Red Sandstone to a consolidated ancient boulder-clay; and more recently (1866) Professor Ramsay has pointed out that the conglomerate of the same age, seen at Kirkby Lonsdale and Sedbergh in Westmoreland and Yorkshire, contains stones and blocks distinctly scratched and with longitudinal and cross striations, like the markings produced by glacial action."

After discussing the value of Professor Ramsay's suggestion which was so much in favour of his own theory, he honestly dismisses it.

> "More evidence, I think, must be obtained before we can feel perfectly convinced that the markings in question had an ice origin."

He finishes Chapter XI with the following remarks on climate :—

> "*The result of our examination, in this and in the preceding chapter, of the organic and inorganic evidence as to the state of climate of former geological periods, is in favour of the opinion that the heat was generally in excess of what it now is. There have been oscillations of temperature, and at least one period of excessive cold of comparatively modern date.......*"

> "If we carry back our retrospect to the primary or Paleozoic ages, we find an assemblage of plants which imply that a warm humid and equable climate extended in the Carboniferous Period uninterrupted from the 30th parallel of north latitude to within a few degrees of the pole."

As regards the still more ancient periods, he says :—

> "A still older flora, the Devonian, so far as we have yet traced its geographical extension, leads to the same inference; and the invertebrate forms of the Devonian, Silurian, and Cambrian rocks have such a generic resemblance to those of the Carboniferous, Permian and Triassic periods, as to imply that a similarity of conditions in regard to temperature prevailed throughout the whole of those six periods."

In discussing the astronomical theory of Mr. Croll, in Chapter XIII., he says (p. 291)—

> "If we now turn from the physical difficulties raised by the astronomical theory to the question of paleontological evidence we find that, if the sketch we have given in the 10th and 11th Chapters of the former state of climate revealed to us by paleontological research be an approximation to the truth, glacial periods have not been perpetually recurring in the northern temperate zone as they ought to have been, were a large eccentricity alone sufficient, apart from the co-operation of all other causes, to intensify the cold of high latitudes. It was shown that the flora and fauna do not exhibit signs of violent revolutions from hot to cold, and from cold to hot periods; on the contrary the continuity of forms from the Carboniferous to the Cretacean period is opposed to the intercalation of glacial periods corresponding in importance to that of Post-Pliocene date."

It is clear, however, that the paleontological evidence to which he refers, as given in the preceding chapters, contains nothing to support his own theory any more than the astronomical theory of Mr. Croll. They furnish evidence of a continuous warm climate in extra-tropical latitudes from the Cambrian period to the latter part of the Pliocene age, but nothing whatever to support his statement that there have been oscillations of climate, during the whole or any part of the long lapse of ages which preceded the supposed glacial period.

His statement that the climate, although evidently warmer than at present, became gradually lowered through the Eocene, Miocene, and Pliocene periods, is entirely in accordance with the view of M. Deshayes cited above, and with the theory of a cooling globe.

The important point in the evidence of a warmer climate in former periods, is not so much that it demonstrates a much higher temperature in former than in later periods, but that it shows in the earlier periods, an equality of temperature in the higher and lower latitudes, which could not possibly have existed if the temperature of the globe depended upon the heat received from the sun. An equality of temperature in the arctic and tropical regions could only be explained by the power of the internal heat being sufficient to maintain a somewhat equal climate over the whole globe, independently of the sun's heat.*

We have observed in a former page that in Chapter IX., which preceded the Chapters treating of "Vicissitudes of Climate," Lyell had given an account of "the development of life in successive geological periods," and had represented the organic remains of animal and vegetable life, discovered in the deposits of successive periods, as shewing a gradual advance in the organization of new forms from the earliest to the latest period.

In telling the story of the evolutionary process, he gives an account of the gradual development of new forms during each succeeding geological period, which would be in harmony with the theory which attributed the development of such new forms in some degree to a gradual change in the physical conditions under which they were brought into existence.

In the latter part of his work he devotes several chapters to the theory of Evolution. He gives a full account of Lamarck's theory of the Transmutation of Species, in which it is shown that Lamarck attributed to changes in the conditions of life, including climate, a very influential part in producing variations in the form and organization of plants and animals.‡

In page 319, Lyell expresses his own belief that changes in physical conditions, including climate, had been a powerful cause in the development of variations in the forms of life, and he refers to his own account of changes in land and sea, and vicissitudes in climate as a record of these changes.

---

*See further as to this below, Chapter III. (p. 26).

‡(See Chapter XXXIII. et seq.)

> "If the reader will reflect on the changes in the earth's physical geography and climate which were alluded to in the first volume (Chapter XI and XII), as having occurred in the course of geological periods, he will not fail to perceive that the new conditions to which plants and animals inhabiting any given province must be exposed, will be far more important in the aggregate than the change of circumstances to which man can, in a few thousand years, subject any animal or plant under domestication."

We submit that the theory of a progressive development in organic forms as pronounced and demonstrated in his Ninth Chapter, is not in accordance with his own theory of "vicissitudes" or "oscillations of climate" which he undertook, but failed, to prove, but that it is in accordance with the facts adduced in Chapters X. and XI., which show a progressive change from a warm climate in the earlier period to a cooler climate in later periods, and which furnish strong support to the doctrine which he had undertaken to confute, that "the gradual diminution of the supposed primitive heat of the globe was the principal cause of alterations of climate."

His theory of repeated changes of climate, involving a recurrence from time to time of hot and cold epochs (even if the cold epochs did not all equal in intensity the cold of the latest supposed Ice Age) implies a sequence of climatic conditions entirely at variance with his theory of the progressive development of organic forms. Nothing could have been more opposed to any advance, or even permanent alteration of organic forms, than a secular alternation of hot and cold climates in the same life areas. If climate or other conditions of life are supposed to have any effect in the change of organisms, it is clear that a system which involved a constant recurrence of the same conditions would be attended by a reversion or stagnation of form, and not by a permanent change or progressive advance.‡

‡ See as to this Wallace's "Tropical Nature," (p. 171 et seq).

On the other hand, the theory of a slow and gradual process of evolution, continued during the long lapse of ages represented in the geological series, resulting in the establishment of a vast variety of permanent forms, as taught by himself in Chapter IX., would be quite in accordance with a gradual and permanent change in the conditions of life, including that of climate, resulting from the slow but uninterrupted process of cooling.

CHAPTER III.

SIR A. GEIKIE'S ACCOUNT OF THE CLIMATE OF FORMER GEOLOGICAL PERIODS.

SIR A. GEIKIE's account * of the climate of the periods preceding the Pleistocene or Quaternary period is in general accordance with that of Lyell, but he takes these periods in their natural order of succession, and not in the topsy-turvey sequence adopted by Lyell. He adopts the same principle of regarding the climate of a period, as demonstrated by the character of the animals and plants living at the time, and he brings forward a much richer representation of the fauna and flora of each period than appears in Lyell's account. He makes no suggestion of any ice action being discovered in periods preceding the supposed Glacial period, but he also omits all notice of the cause of the changes of climate which his accounts testify, except in a slight reference in the Encyclopædia, to Mr. James Croll's astronomical theory.

In his account of the earliest periods—the Cambrian to the Carboniferous—he notices some advance in the organization of life forms, but he does not represent these forms as furnishing evidence of climate. In his account of the Carboniferous period, however, he says—

> "The Carboniferous flora, like that which preceded it, must have been singularly monotonous, consisting as it did almost entirely of flowerless plants. Not only so, but the very same species and genera appear to have then ranged over the whole world, for their remains are found in Carboniferous strata from the Equator to the Arctic Circle."

---

* See "Class Book of Geology," Chapters XVII—XXVII; Encyc. Brit. Vol. X, "Geology."

Whatever his view may have been as to the climate of the tropical region in the Carboniferous period, this statement directly implies that the climate of the northern region, at least up to the Arctic Circle, was the same as that of the Tropics.

As to the flora and fauna of the Permian Age, he says—

> "The total number of species and genera obtained from the Permian rocks, hardly more than 300 in all, forms a singular contrast to the ample assemblage which have been received from the older system. But that the land was at that time richly clothed with vegetation, and the sea abundantly stocked with animal life, there can be no doubt. The flora appears to have closely resembled that of the Carboniferous period; a considerable portion of the plants being survivors from the Carboniferous jungles and forests."

Of the flora of the following period, he says (p. 293) :—

> "The flora of the Triassic period has been preserved chiefly in the dark shales and thin coal seams found in some of the inland basins. So far as known to us it consisted chiefly of ferns, equisetums or horse-tails, conifers and cycads."

In his account of the next period he gives a very distinct intimation that the climate of the Arctic regions in that and the preceding periods had been sub-tropical. (p. 299).

> "The flora of the Jurassic period is marked by the same general characters as that of the Trias; ferns, equisetums, conifers and cycads being its distinguishing elements. Cycads now abound. Among the conifers are the remote ancestors of our 'Puzzle Monkey,' introduced from Chili, and now so common as ornamental garden shrubs (Araucaria Imbricata), and of our pines and firs. This vegetation flourished luxuriantly over the area of Britain, and on the site of Yorkshire it grew so densely as to give rise to thick peaty accumulations, which now form beds of coal. It went far northward, for its remains have been abundantly preserved in Spitzbergen where numerous cycads have been found among them. These plants unquestionably grew and flourished within the Arctic Circle, so that although the climates of the globe were *already beginning to emerge from the greater uniformity of Paleozoic times*, the Arctic region still enjoyed a temperature like that of sub-tropical countries at the present time."

In his account of the climate of the next and most important period—the Cretaceous Period—although he again does not expressly state that the remains of the fauna and flora evinced any change in climate, as compared with that of previous periods, he presents his readers with a marvellous account of the flora of the latter part of this period, which, if the character of the plants living at the time is supposed to furnish evidence of climate, demonstrates that a very marked change had now taken place from the uniform tropical or subtropical climate of the older periods. (p. 314).

> "The plants of the Cretaceous system show that the vegetable kingdom had now made a most important advance in organization. In the lower half of the system the fossil plants, yet found, are on the whole like those of the Jurassic rocks—that is, they include some genera of ferns, cycads, and conifers, which these rocks contained. *But already the ancestors of our common trees and flowering plants must have made their appearance, for in the upper half of the system their remains occur in abundance.* The earliest dicotyledonous flora, numbered among its members species of maple, alder, aralia, poplar, myrica, oak, fig, walnut, beech, plane, sassafras, laurel, cinnamon, ivy, dogwood, magnolia, gum tree, ilex, buckthorn, cassia, credneria and others. *The modern aspect of this assemblage of plants is a striking contrast to the more antique look of the older floras.* There were likewise species of pine (pinus), Calfornian pine (sequoia), juniper, and other conifers, various cycads, forms of screw pine (pandanus), palms (sabal) and numerous ferns (gleichenia, asplenium, &c.) This flora spread over the land, surrounding the Cretaceous basin, and northward *as far as North Greenland, from which nearly 200 species of Cretaceous plants have been obtained.* The inference is that the climate of the globe must have been warmer than at present. The luxuriant vegetation inferred from the Cretaceous rocks of North Greenland, includes more than 40 kinds of ferns, besides laurels, figs, magnolias and other plants, which show, that though the winters were no doubt dark, they must have been extremely mild. There could have been no perpetual frost and snow in the Arctic latitudes in Cretaceous times."

Doubtless these facts show that the climate of the Cretaceous period was warmer than the present, but the more important fact shown by these plant remains would seem to be that the flora of the period included a large number of plants of the same genera as are now living in temperate and northern regions. Such trees as the maple, the alder, the poplar, the oak, the beech, the plane, the ivy, the dogwood, the magnolia, the buckthorn, the pine, the juniper and other conifers, are all hardy plants, which represent the *Northern* flora of the present system.

If plants are evidence of climate, the appearance of such plants in Cretaceous deposits in the Arctic or Northern regions must imply that climatal conditions had now come into play to which this new class of plant forms was adapted.

The plants recorded in the list of the Arctic Cretaceous flora are nearly all deciduous plants, trees and shrubs, which shed their leaves at the end of summer, and do not put them forth until the following spring or summer has brought back the sun's heat. They are adapted both by organization and habit to the seasonal changes of temperature which Northern plants have to contend with, but which are not felt in the Tropics.

Dr. Wallace writes in his "Tropical Nature," (p. 66) :—

> "Atmospheric conditions are much more important to the growth of plants than any others. Their severest struggle for existence is against climate. In the equable equatorial zone there is no such struggle against climate. Every form of vegetation has been alike adapted to its general heat and ample moisture, *which has probably changed little throughout geological periods*."

As to these Northern plants, Major Waddell in his very interesting volume "Among the Himalayas," (1899), makes the following observations with respect to the conditions under which these plants first came into existence. In speaking of the plants which he found living at altitudes of about 15,000 feet, he says (p. 219) :—

> "Plants, however, were not absent on the hillsides, in the crevices, between the stones, but they were almost entirely the (autumnal) remains of flowering plants, and but few grasses, ferns, or other monocotyledons. Mr. Ball observed this peculiarity in the vegetation of high altitudes in Europe, and on this fact is based the belief that flowering plants or dicotyledons originated in the dry and rarified atmosphere of elevated plateaus and mountains. This, too, would explain the absence of well-developed exogens in the tropical coal period, and their late and sudden appearance in the cooler times of the Cretaceous period."

It would seem to be a fallacy to suppose that the temperature of the tropics in the earlier periods would be raised by the addition of the sun's heat to that received from the earth's own store. The effect of the sun's greater heat in the tropics would only be to render the radiation of internal heat much less than in Northern parts where the atmosphere was much colder, owing to the small share it obtained of the sun's heat. A heated cannon ball cools faster in cold air than in hot, not because the hot air enters the cannon ball, but because the heat of the cannon ball does not radiate so rapidly as in cold air. The heat of the tropics would be derived entirely from the internal heat, until that heat became so diminished that the heat radiated from the sun was greater than that radiated from the earth.

The same process of reasoning would seem to explain the uniformity of temperature prevailing over the entire globe in the Carboniferous and the other early periods. The radiation of heat from the earth's interior, which was checked by the sun's heat in the tropics, would be accelerated by its absence in higher latitudes, so that the greater amount of earth's heat passing through the crust in these parts would tend to equalise the temperature of the surface and of the atmosphere lying upon it, with that of the tropics. This uniformity of temperature would only last as long as the internal heat was sufficient to maintain a high temperature in the Northern parts. As the internal heat gradually diminished, the Northern region would become more and more dependent on the sun's heat, and would become affected by the seasonal changes, resulting from the different quantity of sun's heat thrown upon it at different times of the year. This change in the climatal conditions of the Northern regions would have its effect on vegetable and animal life, and would account, according to Lamarck's and Darwin's principles, for the evolution of the new forms discovered in the Cretaceous deposits.

The appearance of these deciduous plants in Northern latitudes in the Cretaceous Period would be perfectly in accordance with the theory that the internal heat had already lost the power of maintaining a uniform temperature in high latitudes, and that although even the extreme north was free from permanent snow and ice the climate was no longer suited to plants accustomed to the same warm temperature throughout the year.

(See further as to this below, Chapter IV.)

In treating of the climate of the next period in the Geological series, he tells us :—

> "The flora of the Eocene time points to a somewhat tropical climate. Among its plants are many which have living representatives now in the hotter parts of India, Australia, Africa and America. Above the ferns, which clustered below, rose clumps of palms, cactuses and aroids. Numerous conifers and other evergreens gave the foliage an umbrageous aspect, while many deciduous trees, ancestors of some of the familiar forms of our woodlands, raised their branches to the sun."

He does not say whether all these different plants were supposed to be living in the same locality, but his list of the deciduous or Northern forms contains nine of the plants mentioned in the list of Cretaceous plants previously given, with the addition of no less than six new forms, with which we are very familiar in this country: the hazel, the elm, the willow, the hornbeam, the chesnut and the plum.

Such a list of Northern plants appears to imply at least a continuance, if not an advance, in the process of refrigeration, whether they were or not accompanied in the same latitudes by survivors of the tropical flora of former periods.

In his account of the climate of the Miocene Period, he tells us that—

> "In the Vienna basin its deposits are well developed and consist of two divisions: (1) a lower group (Mediterranean and marine stage) of limestones, marls, clays and sands, containing an abundant assemblage of shells, some of which belong to species still living in the Mediterranean sea, or off the west coast of Africa, and also numerous remains of land plants, which again recall the living flora of India and Australia; and (2) an upper group (Sarmatian or Cerithium stage) of sands, gravel and clays *in which the shells and terrestrial plants point to a much more temperate climate than that indicated in the lower beds*."

> "Passing beyond the European area we find that some of the characteristic vegetation of Miocene time spread northwards far within the Arctic Circle. In Spitzbergen and in North Greenland an abundant series of plant remains has been discovered, including a good many which also are found in the Miocene deposits of Central Europe. More than half of these are trees, among which are thirty species of conifers, also beeches, oaks, planes, poplars, walnuts, maples, limes and magnolias. This flora has been traced as far as 81° 45′ north latitude, where the last expedition, sent over from England, found a seam of coal 25 to 30 feet thick, covered with black shales full of plant remains."

A comparison of this list with that of the Cretaceous plants found in somewhat the same latitudes shows that the same types of Northern flora still held their ground in the Arctics, if they had not increased. But no mention is made of the presence of any of the old tropical forms, the cycads, the screw-pines, and the palms, which appear in the list of the Cretaceous and Eocene flora.

In his article in the "Encyclopædia Britannica," Sir A. Geikie makes the following observations with respect to the Miocene plants in the Arctic regions.

> "When we remember that this vegetation grew luxuriantly within 8° 15' of the North Pole, in a region which is now in darkness for half the year and is continuously buried under snow and ice, we can realise the difficulty of the problem in the distribution of climate which these facts present to the Geologist."

But the darkness of the long winter does not appear to be an element in the problem which presents much difficulty to the botanist. The whole of the plants in the above list are deciduous in winter, and would suffer no harm from want of light during the months when they were not vegetating, any more than an animal while sleeping.

Nor does the evidence, furnished by this vegetation, of the climate and condition of the Arctics in Miocene times present any more difficult problem to the Geologist than that presented by similar evidence in the accounts of preceding periods. It only shows that the absence of perpetual frost and snow which prevailed in Cretacean times was still continued.

In his account of the climate of the Pliocene period Sir A. Geikie says, (p. 345):—

> "*The flora of the Pliocene period affords evidence of the continued advance of a more temperate climate. The tropical types of vegetation one by one retreated southwards* in the European region, leaving behind them a vegetation that partook of the character of those of the present Canary Islands, of North America, and of East Asia and Japan, but which, as time wore on, approached more and more to the present European flora."
>
> "The fauna presented likewise evidence that the climate, during at least the earlier part of the Pliocene period, still continued warm enough to permit tribes of animals to roam over Europe, the descendants of which are now confined to regions south of the Mediterranean Basin."

In this account, and also in the account of the previous age, Sir A. Geikie expressly recognises a progressive advance in Europe from a warmer to a more temperate climate.

The reader will observe that this view as to the evidence of climate in the Tertiaries coincides very remarkably with that of M. Deshayes, cited above, and with the theory of the older geologists, that this gradual refrigeration of climate was the effect of the diminution of the earth's heat owing to the process of cooling.

It appears, however, that Sir A. Geikie, while restoring to science the old theory of a cooling earth which Lyell had condemned, does not make any reference to it as even a possible cause of the continued advance of a more temperate climate, nor does his account in the "Class Book" suggest any other explanation. But in his account of the Glacial Period in the "Encyclopædia Britannica," he refers to the "luminous writings of Mr. James Croll," and introduces a *resume* of Mr. Croll's hypothesis contributed by that author. It is clear, however, from Mr. Croll's statement that the grounds on which he undertook to elaborate his theory were not only that the old doctrine, of the internal heat of the earth being the cause of the warm climate of the earlier periods, had been abandoned, but that it was also admitted that there was no evidence of a uniform advance from a warmer to a cooler climate.*

We submit that in restoring the doctrine that the cooling of the earth is still a cause in active operation, and in substantiating that principle by the accumulation of evidence now obtained of the proximity of the earth's internal heat to the surface, he has entirely removed the basis on which Lyell's and Croll's theories were founded; however long the time may have been since the earth's internal heat interfered with the dominion of the sun, or played a part in producing the varieties of climate which now obtain in different parts of the globe.

*(See anti, p. 10.)

CHAPTER IV.

Concluding Remarks.

WE have then, in these accounts of the climate of the earth in past ages, as given by Lyell and Sir A. Geikie (passing by the futile attempt of Lyell to substantiate his theory of "vicissitudes in climate,") evidence of the continuance of a uniform warm climate in tropical and extra-tropical regions during the earlier periods, and of a gradual refrigeration of climate, in extra-tropical regions, during the secondary and tertiary periods.

What need can there be to call in "The Story of the Ice Age" to explain the change in the climate and condition of the Arctic regions, at a late stage of the process of cooling, when such a development would be nothing more than its natural and necessary accompaniment?

The following passage from Sir A. Geikie's introductory remarks relating to the Tertiary period has a curious bearing on this question:—

> "*The generally warm climate of the globe, indicated by the world-wide diffusion of the same species of shells in Paleozoic and less conspicuously in Mesozoic times, now slowly passed into the modern phase of graduated temperatures from the great heat at the Equator to extreme cold around the Poles. At the beginning of the Tertiary or Cainozoic periods the climate was mild even far within the Arctic Circle, but at the close it became so cold that snow and ice spread far southward over Europe and North America.*"*

In this passage the writer would seem to have fully adopted the view expressed above, that the evidence furnished by the life remains of past ages shows a progressive advance from a warm to a cooler climate, which began to show its effects

*Class Book of Geology, (p. 328).

on plant life in the Cretaceous age, and became more and more pronounced during the Tertiaries, until it reached the existing phase of climatic conditions, represented by the heat of the Tropics, the snow and ice of the Polar regions, and the occupation of different latitudes by different species of plants and animals. If this were all this passage was intended to convey, the view expressed would be directly in accordance with that of the older geologists before Lyell, and with Sir A. Geikie's own theory of a cooling earth.

It is clear, however, that this is not the purport of the passage. The picture of "snow and ice spread far southward over Europe and North America" has no place in scientific literature, except in the Story of the Ice Age, as told by himself in a future Chapter.

In thus representing the European and American ice sheets of the supposed Glacial Period as a culmination of a progressive change from the warm climates of the Paleozoic and Mesozoic times to the climatal conditions of modern times, the writer is combining two opposite theories of geological climatology. This, however, cannot be done without throwing over altogether the Story of the Ice Age. The period which is supposed to have produced the European ice sheets was not merely a spell of great cold, but a period which included an alternating series of warm and cold climates in the two hemispheres; those of the Northern being introduced into the writer's own version of the story as Glacial and Inter-Glacial Epochs. This so-called "Glacial Period" can have no position in science except as one of a series of similar periods of regular recurrence, which had their origin and termination in accordance with an astronomical theory. Moreover, the Story of the Ice Age, as told by Sir A. Geikie himself, contains, as an essential element, the return of a warm climate after the termination of the "Glacial Period," and the melting of the great ice sheets, which the cold epochs of the "Glacial Period" were supposed to have produced. Had these ice sheets been the culmination of a gradual process of refrigeration which had commenced at the beginning of the Tertiaries, they would most assuredly be in existence now.

The culmination of the slow and gradual process of refrigeration in the climate of the earth, which commenced to show itself in the Cretaceous and early Tertiary periods, was not the fictitious "Glacial Period," but the development of the still existing snow and ice in the Arctic and Antarctic regions, and of glaciers and snow-caps on the higher mountains in all parts of the world, if indeed, as was probably the case, many high ranges had not been permanently glaciated long before the lowlands of the Arctics had been reduced to their present condition.

The disappearance in Scotland, and in other areas of Europe and North America, of the glaciers of former times, does not imply a return of a warmer climate, but, as we have previously urged, the reduction in the altitudes of ancient mountain ranges and other local circumstances, including crust movements, which would alter the climatal conditions of each area, whether in the Arctics or the Tropics.

When the Arctic regions became permanently covered with snow and ice is a question we shall not attempt to discuss. We know that they were free from snow and ice in the Miocene age, except perhaps as Lyell suggests "on the summits of high mountains, and even there, perhaps, not lasting throughout the year."

According to the Story of the Ice Age, the development of snow and ice incident to that event, took place simultaneously with the spread of "the drift," known as the "Diluvial Drift," which was erroneously conceived and represented as the product of ice action. In thus connecting the glacial phenomena of past ages with an entirely distinct class of geological phenomena, the inventors of the story were compelled to represent the development of ice as an event of a passing or periodical character, instead of its being nothing else than an early phase of a process of permanent congelation in high altitudes and high latitudes, which, commencing in remote ages, has obtained with an increased, if not still increasing, intensity, to the present day.

It would appear, however, that the present condition of the Arctics was not reached until a very recent period, geologically speaking, and long after the present European species of animals and plants were in existence.*

The permanent accumulation of snow and ice must have had the effect, not only of lowering greatly the temperature of the Arctic climate, but of excluding from a large area both animals and plants which had formerly occupied it. How far the glaciation of the Arctic region had the effect of destroying its previous occupants, or of dispersing them, except the few which became adapted to the new and very exceptional conditions of life, is a question we must leave to Botanists and Zoologists. Much information on this interesting problem is furnished by Dr. Scharff in his recent work "The History of the European Fauna." Although not excluding altogether the occurrence of a Glacial period of some kind in the Pleistocene period, he reduced it to a nullity by denying that it could have had the effect of producing severe cold in Europe.

He infers from the presence of Alpine plants in Ireland and elsewhere—

> "Not only that the Alpine flora is of preglacial origin, but that the climate of Europe during the Glacial period must have been mild."

He goes on to say—

> "Having now shortly reviewed the state of our knowledge with regard to the former presence in our temperate latitudes of Arctic animals and plants, it still remains for me to give a succinct statement of the light thrown by this fauna and flora on the widespread phenomena of glaciation. It is necessary to do so because, though the greater development of glaciers in the mountains of Europe in former times does not presuppose the

---

*See Darwin's Origin of Species (p. 312).

> prevalence of an Arctic climate, the survival through the Ice Age of a fauna and flora could not possibly have taken place in Northern Europe if the theories of glaciation now so much in vogue were true."

While recognising the existence of larger glaciers on the mountains of Europe in former times, he has freed himself entirely from the dominant fallacy of the glacialists, that their development implied the prevalence of a cold climate in Europe, any more than (as we have previously pointed out) the present glaciers in the Himalayas or in the mountains of Central East Africa imply a glacial climate in India or Africa at the present time.

In conclusion, we must repeat our opinion that the "Story of the Ice Age" has no place in a geological system which includes the doctrine of a still cooling earth.

Apr 1961 - La Vie Rustique

[illegible]

card

3 0112 115545573